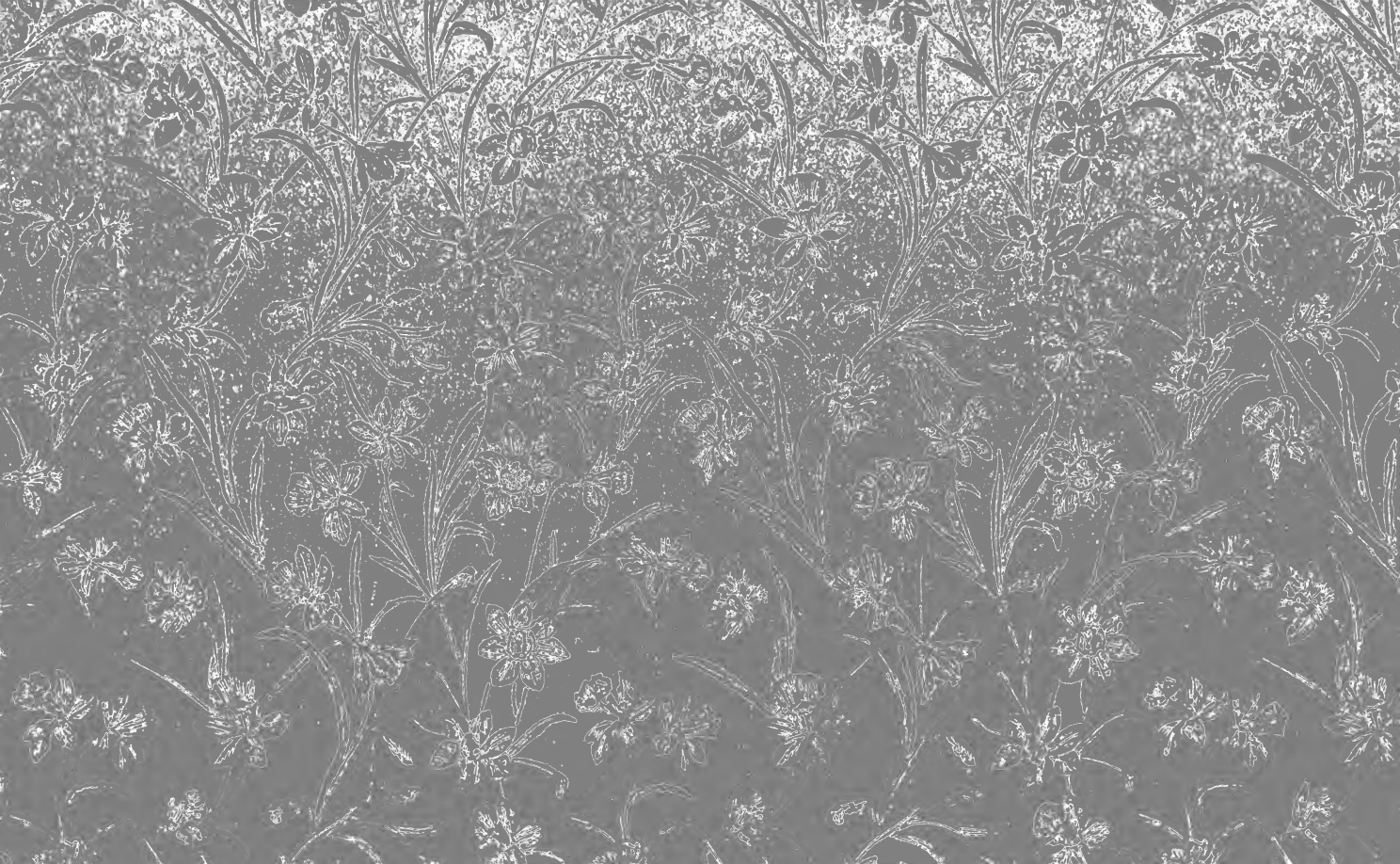
THE RECOGNITION OF OCULAR DISEASE.

FORREST.



The Recognition of Ocular Disease.

A TREATISE FOR OPTICIANS.

By

JAMES FORREST, M.B., Ch.B. (Edin.)

Late Surgeon Eye and Ear Hospital, Croydon; Chief Resident Medical Officer at Central London Ophthalmic Hospital, St. Mary's Hospital, Plaistow, E., and Throat Hospital, Golden Square, W.; Chief Clinical Assistant at The Central London Eye Hospital, Gray's Inn Road, at Moorfields, City Road, and at the Throat Hospital, Golden Square, W.

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PREFACE.

The following pages have been written in the hope that they may prove of service to those opticians who desire to obtain a general knowledge of Eye Diseases. To render these more intelligible a chapter on Elementary Physiology and Pathology has been inserted.

In my endeavour to make this a concise and practical treatise I have laid the greatest stress on those conditions which the reader may meet with in the course of his practice, and have excluded or dealt summarily with those he is unlikely to encounter.

Typical illustrations of nearly all Diseases are given, and it is hoped that these, together with the short descriptions, will enable the student to avoid the many pitfalls with which the path of the optician is strewn.

Finally I desire to express my deep sense of gratitude to Mr. H. L. Taylor, not only for correcting the proofs, but also for many valuable aids and suggestions which have both lightened and added confidence to my labours.

J. F.

July, 1911.

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PHYSIOLOGY AND PATHOLOGY.

Chapter I.

PHYSIOLOGY.

To understand the action and working of the human body, which consists of distinct but connected parts, it is first of all necessary to examine its general structure. The adult body consists of a great number of different parts, each having its own special work to do, and whose vitality is dependent upon that of the body as a whole. These parts of the body are called "organs," and each does not only its own special work, but acts in harmony with all other organs, which become grouped into what are termed "systems." Thus the circulatory system includes the group of organs concerned in the circulation of the blood, viz.:—heart, arteries, veins, capillaries, etc.; the respiratory system is concerned in the act of breathing; the digestive system deals with the digestion of food; the excretory system with the getting rid of waste products; the muscular system with movement; the skeletal system with the framework supporting the softer parts of the body; and over and above all, there is the nervous system (brain, spinal cord, and nerves), which presides over, controls, and regulates the functions of the other systems.

An examination of an organ reveals the fact that it consists of various textures termed "elementary tissues," just as a house is made up of stone, wood, iron, mortar, and other substances.

The elementary tissues come under the four following headings:—

1—Epithelial Tissues.
2—Connective Tissues.
3—Muscular Tissues.
4—Nervous Tissues.

These individual tissues, when examined microscopically, are seen to consist of masses of minute cells united together by different amounts of cementing material, just as the wall of a house is made up of bricks united by cement. One tissue differs from another in the form and nature of its cells, and in the varying amount of the intercellular substance.

The term cell was first used by botanists. In the popular sense of the word a cell is a space surrounded by a wall, as a prison cell or the cell of a honeycomb. Now a vegetable cell has a wall (composed of cellulose) surrounding it, but an animal cell differs from it in possessing no such wall, and is merely a little naked lump of living material of jelly-like consistence, possessing the power of movement, and to which the name "protoplasm" has been

given. Somewhere in the protoplasm of all cells is a roundish structure, more solid than the rest of the protoplasm, called the nucleus, and frequently there is also a clear space called a "vacuole." An animal cell, then, is a mass of protoplasm, containing a nucleus. The simplest animals, like amœbæ, consist of one cell only; the simplest plants, like bacteria, consist of one cell only. These organisms are called unicellular, and in the progress of their life history the cell divides into two, the two new cells separating and becoming independent organisms, each repeating the process later on. In higher animals and plants, though unicellular to start with, the division and sub-division of the cells results not in separation but in combination, though the different cells become highly differentiated, being modified according to the special functions they have to perform. A living cell possesses the power of assimilation, or ability to convert into protoplasm the nutrient material or food which is ingested. It also has the power of growth, which is a natural consequence of the power of assimilation, the power of reproduction, and the power to excrete its waste materials—the products of its activities. Living material is in a continual state of unstable chemical equilibrium, building itself up on the one hand, breaking down on the other, the term used to indicate these intramolecular rearrangements being metabolism.

The higher one ascends in the animal scale the more highly differentiated do the various cells become, and we classify them (according to the function they subserve) as bone cells, muscle cells, nerve cells, glandular cells, etc. We will now briefly review the various kinds of tissues in the body.

Epithelial Tissue.—This is the substance which forms the outer layer of the skin of the body, and lines all the passages and cavities communicating with the outside of the body, and also all closed tubes and cavities. Microscopically it is seen to consist of variously shaped cells cemented together. Its chief function is protective, and the greater the need for such protection the harder and more horny is the tissue. The soft skin lining internal passages, such as the nose, throat, air passages, conjunctiva, etc., is called "mucous membrane," because some of the cells form a thin, viscid and slimy fluid called mucus, which lubricates and so reduces the friction of surfaces.

Connective Tissue.—This, as its name implies, unites different organs, and also binds together the various parts of an organ. It is found in all parts of the body, uniting the skin to the structures beneath, surrounding and penetrating muscles, and forming a sheath for nerves, blood vessels, etc.

Under the microscope it is seen to consist of fibres of two kinds, with cells, called connective tissue cells, around and between them. One kind of fibre, arranged in bundles following a wavy course, is inelastic, and is called "white connective tissue," whilst the other kind consists of fine, straight, elastic fibres, and is called "yellow elastic tissue." Connective tissue fibres may be dense and closely arranged, as in the sclera, or they may be open (forming a network) as beneath the skin. In the latter case spaces called areolæ, containing a clear fluid, lymph, lie between the fibres. When these spaces are very large, as those beneath the skin, the tissue is called "areolar tissue." When the

support required is of a firm character the connective tissue consists of closely packed bundles of white fibrous tissue, the number of elastic fibres present depending upon the amount of resilience required, as in ligaments which bind bones together; but when the support needed is merely that of a loose connection, as in the union of the skin to the subjacent structures, then the bundles of fibrous tissue are widely separated by that serous fluid which pervades and surrounds all tissue to a greater or less extent.

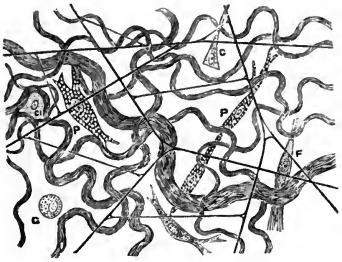


Fig. 1.

Connective tissue, highly magnified. The elastic fibres form an open network, the white fibres being in wavy bundles. *P* Plasma cells. *G* Granule cell.

Bone is a variety of connective tissue in which lime salts are deposited between the fibres, thus forming the most solid tissue in the body.

Blood is another variety of connective tissue, and represents the most fluid tissue in the body, being a liquid structure holding in suspension large numbers of solid particles called corpuscles The fluid part of the blood is called plasma, or liquor sanguinis, and consists of 90 per cent. water and 10 per cent. solids, the latter being chiefly proteids, with a little fat, and inorganic salts. The corpuscles are of two kinds, red and white, the latter being typical amœboid animal cells. The red corpuscles are much more numerous (about 450 times) than the white, averaging in man 5,000,000 per cubic millimetre, and they impart to the blood its red colour. When

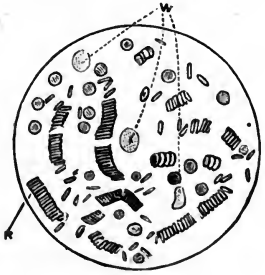


Fig. 2.

Blood under the microscope, showing red corpuscles (*R*) in rouleaux and singly. At *W* are seen the white ones.

blood is shed it rapidly sets into a jelly and clots. This jelly contracts and squeezes out of the clot a straw coloured fluid called serum, in which the

shrunken blood clot floats. The clot consists of threads of fibrin, in the meshes of which the blood corpuscles become entangled. Thus blood serum is plasma minus fibrin.

The red blood corpuscles in a freshly drawn film of blood arrange themselves in rouleaux, like piles of coin. They consist of a delicate, colourless elastic envelope with coloured fluid contents, the latter being mainly a solution of red substance called hæmoglobin, which is a complex nitrogenous compound containing iron. This hæmoglobin is of great importance, as it forms a loose combination with oxygen, acting as the oxygen carrier of the blood. It always contains some of this gas, but when saturated with oxygen it becomes of a brighter red colour, and is termed oxyhæmoglobin, and when deprived of it, reduced hæmoglobin, which is of a darker red colour. Hence arterial blood is bright red, and that in the veins dark red.

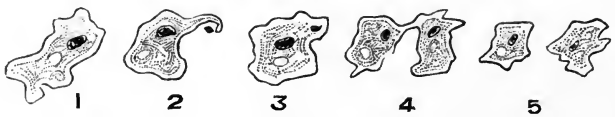


Fig. 3.

An amœba, showing granular protoplasm, nucleus, and small vacuole. At *2* it is throwing out a process to take in a particle of food; at *4* it is dividing into two, the nucleus already having divided; at *5* division is complete, each part having its own nucleus.

The white corpuscles, often called leucocytes, are of irregular shape, and microscopically they may be seen altering their form, as, like the amœbæ, they are capable of spontaneous movement and division. They are true cells, consisting of nucleated protoplasm, and they thus act like tiny living creatures, creeping from place to place by putting out and drawing in processes, taking up particles of foreign matter which they encounter on their way. At times they make their way out through the thin walls of the minute blood vessels into the surrounding tissue, especially when an injurious foreign body intrudes into the tissue. These white corpuscles or leucocytes are the scavengers of the system, and their function is to engulf and remove all harmful bodies.

The blood supplies nutriment to cells and tissues of every organ of the body, obtaining its nutritive matter from the digested food in the alimentary canal. It further carries away from all parts waste material, which is afterwards removed from it by excretory organs such as the kidneys. Another function, performed by the red corpuscles, is to carry oxygen to the tissues, which take it up and unite it with some other element or compound, resulting in the formation of substances of no further use to the body, and which are termed waste products. The most abundant of these waste products is carbonic acid gas. The tissues take oxygen from the blood, and return it later as carbonic acid gas (CO_2).

The blood, during life, is in constant motion, leaving the heart by the arteries, and returning to it by the veins.

The heart consists of four chambers, two on either side, the right and left auricles, and the right and left ventricles. Venous blood flows into the right auricle, and then into the right ventricle, which pumps it into the lungs *via* the pulmonary arteries. Here the venous blood gives up its carbonic acid to the air in the lungs, and takes from it oxygen, the blood and air being separated only by two exceedingly thin membranes, through which the gases can readily pass. The oxygenated (arterial) blood flows back *via* the pulmonary veins to the left auricle, and passes into the left ventricle, from which it is pumped into a large arterial blood vessel called the aorta, and thence to all the arteries in the body. (See Fig. 6.)

As the aorta receives all the arterial blood from the left ventricle, it is, of course, the largest artery in the body; but, owing to the branches it gives off, it gradually diminishes in size, and finally divides into two main branches, which in their turn further divide and sub-divide, each branch or sub-division being smaller than the preceding artery. The larger arteries have very thick walls, which are composed of three layers: (1) a thin internal lining of epithelial cells, united together at their edges by a little cement; (2) a middle muscular coat; (3) a tough outer coat of connective tissue. Their lumen, or internal diameter, varies from $\frac{1}{8}$in. in the aorta to 1/32 in. in the smaller arteries. The smallest arteries gradually lose their outer and

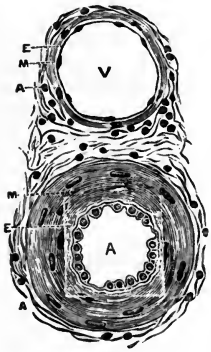


Fig. 4.

Magnified section of small artery *A*, with vein *V*. *E*, Cells of inner coat. *M*, Muscular coat, with connective tissue beyond, the nuclei of connective tissue corpuscles being seen.

middle coats, and later become so small that their diameter is only about 1/3000th of an inch, there being left only the inner lining of endothelial cells to form their exceedingly thin walls. These vessels are called capillaries, and it is whilst passing through them that the arterial blood gives up its nutriment and oxygen to the surrounding tissue, and receives carbonic acid gas and other products of oxidation in return. There is only one thin membrane separating the blood from the surrounding tissue and fluid, and this readily permits of diffusion. These capillaries gradually increase in size, owing to many joining together, and hence the volume of blood becomes greater. The wall now becomes strengthened by an additional coat, and then the vessel is termed a vein. These veins unite together to form

larger ones, which in their turn unite again, until near the heart there are only two large venous trunks, called venæ cavæ, conducting the blood into the right auricle. Thence the blood passes into the right ventricle, which pumps it through the pulmonary arteries into the lungs. Here the dark venous blood gives up its carbonic acid and takes in oxygen, returning to the heart by the pulmonary veins. It passes into the left auricle and then into the left ventricle, which again pumps it into the aorta. The orifices connecting the vessels with the heart, and also the various compartments of the heart with each other, are guarded by valves which allow of the flow of the blood in one direction only. Veins also possess numerous valves for the same purpose, but there are none in the arteries.

Blood pressure and the pulse.—The aorta and the chief arteries have so much elastic tissue in their walls, that they are really elastic tubes, and this elasticity plays an important part in the circulation of the blood. During life the arteries are always so full of blood that their walls are tense, and this pressure on the arterial walls is called the blood pressure. It is shown by the spurting out of the blood when any large artery is cut, or by placing a vertical tube in an artery, when, in the case of the large arteries near the heart, the blood will be forced up about five feet. Just as the blood is pressing against the wall, so is the latter, in virtue of the elastic fibres it contains, pressing with equal force upon the contained blood, squeezing the latter onwards towards the capillaries, as it is prevented from going back into the heart by the closure of the valves. At each contraction of the ventricle more blood is forced into the already distended aorta, stretching it still more, and this extra expansion is reflected quickly as a wave along all the arteries, constituting what is known as the pulse.

The pulse wave travels at the rate of 30 ft. per second, but does not, as a rule, extend into the capillaries and veins, becoming extinguished by the friction that the blood in its progress has to overcome, especially from the greater total sectional area of the capillaries, and in these the jerky arterial flow becomes converted into a steady and continuous one.

The left ventricle, in health, contracts about 72 times to the minute, as is evidenced by the pulse rate, and during each contraction the arterial blood pressure is, of course, raised. The blood pressure is greatest in the arteries, less in the capillaries, and least in veins, but the onward flow in the veins is arrested by muscular movement and respiration, valves in the veins preventing the blood from flowing backwards. This pulse wave must not be confused with the flow of blood, the latter being much slower, only about a foot a second.

We have seen that the blood circulates in a system of tubes, the smallest, the capillaries, being so numerous as to form a close network in all tissues. These capillaries have exceedingly thin walls, composed of only a single layer of flattened cells united together at their edges. Through these thin walls oxygen and part of the blood plasma (the fluid portion of the blood) pass by diffusion into the surrounding tissue, thus providing nutriment for the adjacent cells and fibres. This nutrient fluid,

oozing out of the capillaries and bathing the living tissues, is called *lymph*. It is important to note that there is no actual contact

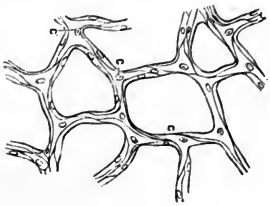


Fig. 5.

Highly magnified capillaries, showing walls of single layer of nucleated epithelial cells. *C* shows junctions of vessels.

between the blood and the tissues, but that the thin membrane separating the two in the capillary vessels allows of the diffusion of this lymph, which acts the part of middleman between the blood and the tissues. The cells and fibres of the tissue are thus bathed in lymph, and from it they take up nutriment, whilst into it they excrete their waste products.

Lymph is a colourless fluid containing in solution, like the blood plasma, proteids, carbohydrates and salts, though the proteids are somewhat less, and the water more in proportion. It also contains some white corpuscles, which have passed out of the blood capillaries, but few or no red ones. Like blood plasma, it possesses the power of coagulating. As well as the oxygen and nutritive material passing from capillaries to the lymph and into the cells, there is also a passage, in the opposite direction, of carbonic acid and waste material from the tissue cells to the lymph, thence into the capillaries, and onwards into the veins to the lungs, etc. A certain quantity of the lymph in the tissues does not find its way into the capillaries, but returns to the blood stream in a roundabout way.

Lymphatic vessels.—The excess of lymph from the blood, and the white blood cells present in it, which do not return into the blood capillaries, lie in minute spaces between the cells of tissues, and these spaces are drained by very small tubes which begin in the tissue, and are called lymphatic capillaries. These unite to form larger lymphatic vessels, and the lymph is carried by these vessels to be emptied into the venous blood stream at only a short distance from the latter's entrance into the heart. Lymphatic vessels have valves in their interior like the veins, the free edges of which point towards the heart, and the pressure, caused by muscular movements, drives the lymph onwards towards that organ, the valves preventing any reflux.

The lymphatic vessels of the small intestine are designated lacteals, because, besides imbibing tissue lymph, they absorb from the intestines the emulsified fat of the food, and thus, after a meal, become filled with a white milky looking fluid called chyle. The carbohydrates and the proteids of the food. on the other hand, pass from the intestine directly into the blood stream through the walls of the blood capillaries.

The thoracic duct.—All the lymphatic vessels from the lower limbs, the lower part of the trunk, the intestines, and the left side of the body, discharge into a large trunk vessel called the thoracic duct, which opens into the large veins at the root of the neck on the left side. The lymphatics from the right side of the head and neck, and from the right upper limb, open by a common vessel into the veins on the right side of the neck.

Lymphatic glands.—Both the lymphatic vessels and lacteals from the intestines pass, on their way to the thoracic duct, through small structures termed lymphatic glands, which are really factories for the production of white blood cells, and as the lymph percolates through the gland it carries away with it many of these new colourless corpuscles. Lymph glands also act as filters, the white cells present seizing and destroying any foreign body in the lymph, such as bacteria, dust particles, etc.

A short consideration of the whole vascular system, including blood, lymph and chyle, assisted by a diagrammatic figure, will serve to render the

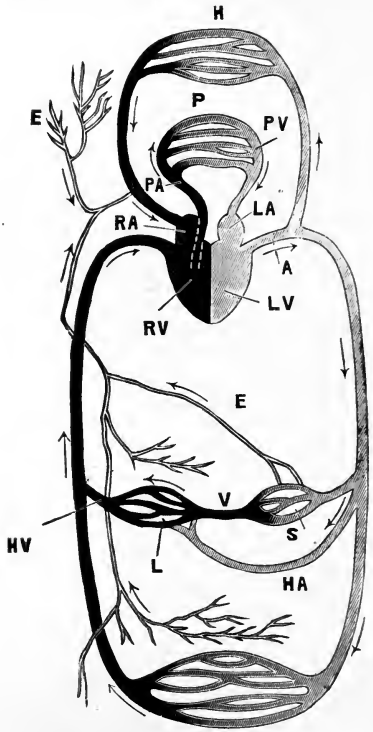


Fig. 6.
Diagrammatic representation of the circulation.

subject more lucid. The arterial blood is shown shaded, the venous black, and the lymphatics white, arrows indicating the direction of the flow of

blood and lymph. Venous blood is collected from the capillaries of the head and neck, H, by the upper vena cava, from the capillaries of the extremities and trunk, shown at the bottom of the figure, by the lower vena cava, and by these two great veins it is emptied into the right auricle, RA. From the right auricle it flows into the right ventricle, RV, which propels it into the lungs, P, through the pulmonary arteries, PA. Here the venous blood gives up carbon dioxide and receives oxygen, becoming converted into red arterial blood. From the capillaries of the lungs the purified blood passes by four pulmonary veins represented by PV, into the left auricle, LA, and from this into the left ventricle, LV. This then propels the blood into the aorta, A, which gives off branches above to the head and neck, and below to the stomach and intestines, S, to the liver, L, and to the smaller arteries and capillaries of the other parts of the body. It will be seen that the venous blood from the stomach and intestines, S, which is loaded with nutriment derived from those organs, does not pass directly into the general venous system, but first enters the liver, L, by the portal vein, V., uniting in the liver with the pure blood of the hepatic artery, HA, the blood from both these vessels leaving the liver by the hepatic vein, HV, to empty into the lower vena cava. This part of the circulation is called the portal circulation.

The diagram also represents the lymphatic system of vessels, the latter being represented by E, arising in all the tissues and organs, and conveying away lymph. Most of these vessels unite to form a large trunk, the thoracic duct. The lymphatic vessels from the intestines are called lacteals, because, during digestion, they convey with the lymph a milky fluid called chyle.

Blood, therefore, becomes venous in the systemic capillaries of all parts by giving up, through the exuded lymph, some of its oxygen and nutrient matter, and by taking from the tissues carbon dioxide and other waste products. Blood becomes arterial in the capillaries of the lungs, where it gives up some of its carbonic acid and water, by taking in oxygen again, but venous blood contains a little oxygen, just as arterial blood contains a little carbonic acid.

Muscular Tissue.—It is expedient to introduce here a few remarks on the skeleton of the body, in order that the subsequent observation on muscle may be the more easily understood. The whole of the bones of an animal in their natural position constitute the skeleton, and in the human skeleton there are more than two hundred bones, which are variously united together so as to form joints or articulations. The bones form the framework for the body, supporting the soft parts, protecting important organs, and giving attachment to the muscles of the body. The principal parts of the skeleton are the spinal column, with the appended bony thorax (chest), the skull, the bones of the arms, with the scapula (shoulder bone), and clavicle (collar bone), to which each arm is connected above, and the bones of the legs, which are attached through the pelvis (hip bones) to the lower portion of the spinal column. The various bones of the skeleton are kept together chiefly by tough fibrous bands called ligaments, also by atmospheric pressure, and by adhesions due to close contact, and their connection is made in various ways, sometimes admitting of no movement between the two adjoining bones, at

others allowing more or less range and variety of movement. The union of two contiguous bones, together with the parts forming the connection, is called a joint or articulation, and we divide these into immovable and movable joints.

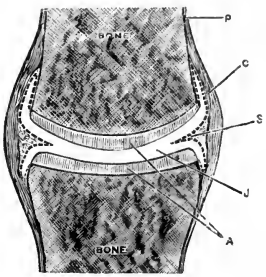


Fig. 7.

Section of a joint. The dotted line represents the synovial membrane, the articular surfaces being really in contact. *P* Periosteum. *C* Capsule. *S* Synovial fold. *J* Joint cavity. *A* Articular cartilage.

Bone, as we have previously observed, is a form of connective tissue, in which inorganic material (chiefly calcium salts) is impregnated around and between the fibres. It is covered by a fibrous membrane called periosteum, containing many small blood vessels, which supply the outer layers with nutriment. The inner part, called the marrow, is much softer and less compact than the outer layers, and in the larger bones blood vessels run through the outer compact layers to supply nutrient material to the marrow. Many of the smaller bones have no canal with marrow within, but only a thin, hard, compact layer beneath the periosteum, with spongy tissue within.

The ends of bones which are joined together to form a movable joint are tipped with cartilage, the free surface of which is smooth, and the ends of the bones are also united by tough bands of fibrous tissue, called ligaments. One of the ligaments forms a sort of loose bag all round the joint, and is called the capsular ligament, or capsule. This ligament has a delicate lining, the synovial membrane, which secretes a viscid fluid serving to lubricate the heads of the bones, and to prevent friction.

The skeleton of the body, made up of numerous jointed bones and cartilages, not only acts as a framework, but the bones furnish points of attachment for muscles, the latter being commonly called flesh. The muscles, using the bones as levers, are the agents which bring about movement, and are of various shapes, the prominent ones being usually spindle shaped, thicker in the middle than at the ends, where they terminate in one or more white fibrous, inelastic cords termed tendons or sinews.

These must not be confused with ligaments, which are the strong fibrous bands binding parts together, especially keeping the bones in place at the joints. A muscle, of course, has two attachments, the more fixed or central one is called the origin, and the more movable or peripheral attachment

the insertion. For instance, the external ocular muscles are said to arise from the more fixed bony orbit, and are inserted into the more movable eyeball. The tendon, nearly always much more marked at the insertion end of the muscle, blends with the periosteum of the bone. Muscular

Fig. 8.

A Muscle, showing the tissue passing at each end into tendinous tissue. *O* Origin. *S* Sheath. *T* Tendon of insertion.

tissue possesses the power of shortening or contraction, so initiating movement. Muscles are divided physiologically into two great classes; the voluntary or striped, which are under the control of the will, and the involuntary, or unstriped, as the iris and pupil, which are not, the latter constituting only a very slight percentage of the muscular system, being confined chiefly to the vascular system. The voluntary muscle, by the naked eye, is seen to consist of small longitudinal bundles termed fasciculi, each fasciculus being covered by a sheath of membrane, derived from the sheath known as fascia, which invests the whole muscle. When a fasciculus is examined microscopically it is seen to comprise a number of fine muscular fibres running lengthwise, and consisting of a semi-fluid, contractile substance, termed muscle plasma, enclosed in a transparent elastic sheath called the sarcolemma of the fibre. Just underneath this membrane can be seen a nucleus. Such a fibre averages about 1 inch in length, but only 1/400th inch in diameter, and when seen under the microscope it shows an alternate dim and light cross striation, hence the name striped muscular fibre. The muscle fibres are joined together by delicate connective tissue

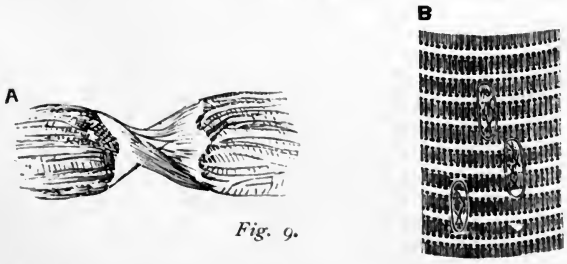


Fig. 9.

A Muscle fibre torn across, the sarcolemma still joining the two parts. *B* Muscle fibre highly magnified, showing striations and the elongated oval nuclei.

(perimysium internum) which also binds the fasciculi together (perimysium externum), and this is continuous with the connective tissue sheath surrounding the whole muscle. These various connective tissue membranes, penetrating between muscles and their parts, convey the arteries, veins, capillaries, and nerves. Capillaries do not enter the muscle fibre, the lymph diffusing through the sarcolemma.

Unstriped, or plain muscular tissue, consists of fibres that do not show the alternate light and dark striation, each fibre being a spindle-shaped cell with an oval nucleus. Plain muscular fibres are never found attached to bones, but are associated with other tissue, as in the walls of the alimentary canal (stomach and intestines), of blood vessels, etc. A muscle, on being excited or stimulated, contracts by drawing its ends nearer together, at the same time becoming harder and thicker in the middle, though it does not become smaller in bulk. The amount of shortening varies, so that the length of the muscle, when contracted, is from 65 per cent. to 85 per cent. of what it was originally. Each single fibre forming the muscle becomes shorter and thicker, and as all of them contract at the same time, the muscle contracts as a whole. Contraction may be brought about by direct incitation (electrical, mechanical, etc.), but ordinarily it is set up by a nervous impulse. Besides that of form, muscle undergoes changes of temperature, electrical condition, extensibility and elasticity. There are also chemical changes, because, like other living tissues, muscle is taking oxygen and nutriment from the blood, whose complex substances are constantly being oxidised into simpler ones, as carbonic acid, etc. The contracted state of a muscle can only endure a short time, this soon being followed by relaxation, and a return to its normal length, but contraction can be excited again after a very short interval of rest. The involuntary muscles contract and relax much more slowly than the voluntary.

Though each muscle has a definite action, generally pulling along an axis running between its two points of attachment, yet it must be borne in mind that hardly any single muscle acts alone. Each muscle, as a rule, forms one of a group, acting more or less in harmony with, and antagonised by, other and opposite groups.

Nervous Tissue.—This is the highest form of all tissue, all the actions of life being regulated by one part or another of the nervous system. It controls muscular action, regulates the processes of secretion in the various glands, and determines the amount of blood supply to a part by acting on the smaller arteries. The impressions of the outer world are also registered by it, and it connects the various parts of the body with each other, co-ordinating them into one harmonious whole. Its relatively great bulk and its extreme complexity constitute two of the most distinctive structural features in man. It is somewhat arbitrarily divided into two closely related parts, the cerebro-spinal nervous system and the sympathetic nervous system.

The cerebro-spinal system consists of the brain, which occupies the cranial cavity, and the spinal cord, lying in the spinal canal, which runs

through the centre of the vertebrae. These are continuous with each other, and together constitute the cerebro-spinal axis. Attached to the brain and spinal cord are the numerous nerves which connect the various parts of the body with the central nervous system. There are twelve pairs of cranial nerves, and thirty-one pairs of spinal nerves.

The brain and spinal cord are composed of two substances, presenting a different colour to the eye, viz., white matter and grey matter. The former consists chiefly of nerve fibres, the latter of nerve cells. The elements constituting nervous tissue are nerve cells, nerve fibres, and a connective tissue called neuroglia.

Nerve cells are of different shapes, often irregular in form, and they vary in size from 1/400in. to 1/4000in. The cell consists of a nucleated mass of protoplasm, from which certain processes extend. According to the number of processes they possess, they are called unipolar, bipolar, or multipolar. Most of these processes break up into branches called dendrons, but one process is distinguished from the rest by non-branching. This unbranched process is continuous with the central part or axis cylinder of a nerve fibre, and is called the axon of the nerve cell. Each nerve cell, with its axon, is an independent structure, and the connection of one nerve cell with another is made by the adjoining of the fine branches, although there is no actual union of these.

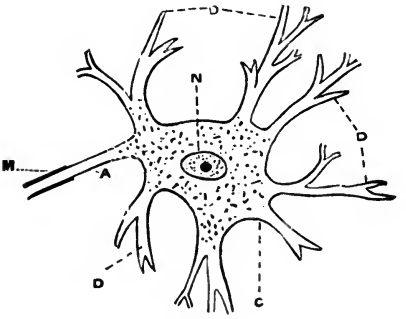


Fig. 10.

Multipolar cell from grey matter of spinal cord (highly magnified). *A* Axon, with medullary sheath *M*. *C* Cell body. *N* Nucleus, with nucleolus. *D* Branching processes, which often interlace with those of other cells.

Nerve fibres.—The cranial and spinal nerves appear to the naked eye as white cords, which, on being teased out and microscopically examined, are seen to consist of bundles of fine fibres held together by their connective tissue, this passing not only between and around the bundles, but also around the individual fibres. The nerve fibre is about 1/400th of an inch in diameter, and appears microscopically to consist of three parts. :—

(1) A central core of semi-solid matter called the axis cylinder, which is the conducting portion of the fibre.

(2) A medullated sheath, fatty in nature, serving to insulate and protect the axis cylinder. Sympathetic nerve fibres do not possess this sheath, nor do the optic nerve fibres in the retina, except in abnormal cases, when they appear ophthalmoscopically as a glistening white area continuous with the disc.

(3) An outer sheath, called the neurilemma, with a nucleus lying between it and the medullated sheath.

A nerve fibre is directly continuous by one extremity with a nerve cell, whilst its opposite extremity breaks up into a number of ramifications, ending freely in relation to another cell or to certain tissues of the body, as a muscle fibre, etc., and hence the length of nerve fibres varies greatly.

Nerve fibres merely conduct the nervous impulse generated by the cell, and so we divide them into two sets. Firstly, there are afferent fibres, which conduct the impulse of impressions from the peripheral organs to the brain, giving rise generally to a sensation of heat, light, sound, etc., and hence often called sensory nerves. Secondly, there are efferent fibres, which conduct the impulse from the central nervous system to the muscles, glands, etc., and are called motor nerves. Nervous impulses are conducted normally in only one direction; in efferent nerves from, in afferent nerves to, the nerve centre. When a nerve fibre is divided, that part cut off from the cell degenerates, but later the fibre commences to grow from the other cut end.

The nature of the nerve impulse is not known, but it is accompanied by electrical changes in the nerve fibre, and the velocity of the impulse is estimated at about 100 feet per second.

The brain is enclosed in the skull, which is a bony box of many pieces, fitted together by sutures. Besides this bony case the brain is invested by three membranes, firstly, a tough one called the dura mater, which lines the cranial bones and forms its outer covering, closely investing the brain itself, and dipping down into all its furrows. The innermost is a more delicate vascular membrane, called the pia mater, which largely supplies the brain with nourishment. Between the two is another called the arachnoid, large lymph spaces also existing between pia and dura mater and the arachnoid.

The brain is an exceedingly complicated structure, and only a bare outline of it will be given here. At the lowest part, continuing the spinal cord upwards is the medulla oblongata; next comes the pons Varolii, or bridge which connects the cerebellum or small brain with the cerebrum or large brain. Through the brain runs a cavity filled with fluid and lined by epithelium. This is continuous with the central canal in the spinal cord, and also with the lymph spaces between the membranes of the brain, and through these with the lymph spaces in the nerve sheaths. Any increase of pressure within the brain is manifested in the nerve sheaths, as is evidenced by the appearance of choked discs (see Chap. XIII.) in brain

tumor. The surface of the brain is convoluted, and fissures also run through part of it.

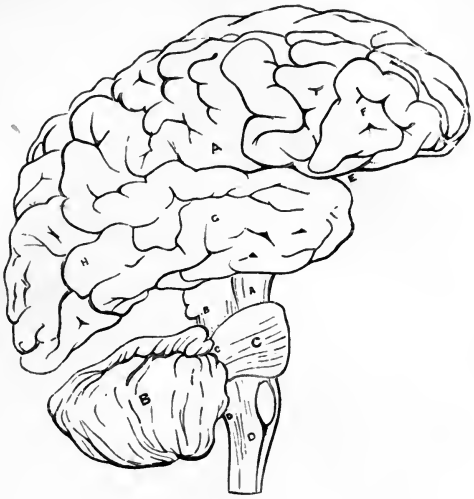


Fig. 11.

Plan, in outline, of the human brain as seen from the right side, the parts being separated from one another more than is natural, in order to show their connections plainly. *A* The cerebral hemisphere, showing fissures and convolutions. *B* Cerebellum, which is connected with the cerebral hemisphere by the peduncle. *C* Pons varolii. *D* Medulla oblongata, which is continuous below with the spinal cord.

Continuous with the lower portion of the brain (the medulla oblongata) is the spinal cord, which lies in the canal between the vertebræ. The spinal cord consists of a central mass of grey nerve cells, the motor cells being stationed anteriorly and the sensory ones posteriorly. Outside the grey cells are placed numerous afferent and efferent white conducting nerve fibres. Sensory nerve fibres arise from the posterior grey cells, and motor fibres from the anterior grey cells. Outside the cord they join to form a single mixed nerve.

Sensations that arise on the skin or extremities of the body muscles are conducted by the afferent nerve fibres to the spinal cord, and on through the medulla, in order to reach the cerebral hemispheres, where alone they are interpreted. Also voluntary impulses pass from the cerebral hemispheres through the medulla and cord, to reach the motor or efferent fibres that put in action the muscles, glands, etc. Sensations from the face and head pass into the cranial nerves, which pierce the skull in order to enter the brain directly, and the motor fibres pass out in the same direction.

Both spinal and cranial impulses are appreciated in the other side of the brain from that of the body from which they emanate, as all the nerve fibres of one side of the body cross over to reach the other side of the brain, and so injury of one side of the brain produces paralysis and loss of sensation in the opposite side of the body.

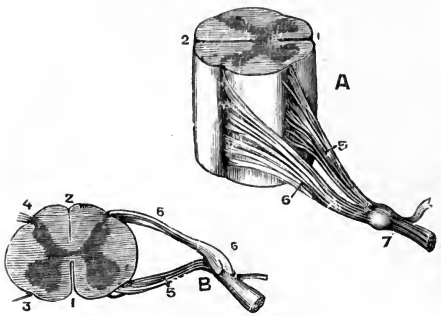


Fig. 12.

Diagrammatic transverse sections of the spinal cord.

A, showng a small portion of cord. (1) Anterior fissure between the two sides on the one of which the anterior grey root is shown, with motor fibres (5) arising from it. (2) Posterior fissure to one side of which is the posterior grey root, with sensory fibres (6) arising from it. (7) Mixed nerve, with sensory and motor fibres. *B* showing a thin section of cord. The darker coloured central area represents the grey cells, and the lighter coloured peripheral area the conducting afferent and efferent fibres. The numbers are as in *A*, (3) showing the anterior grey root, and (4) the posterior grey root.

Reflex action.—The spinal cord not only acts as a conductor of impressions and impulses, but it also has reflex functions. It conducts motor impulses from the brain to the muscles, and also sensory impressions to the

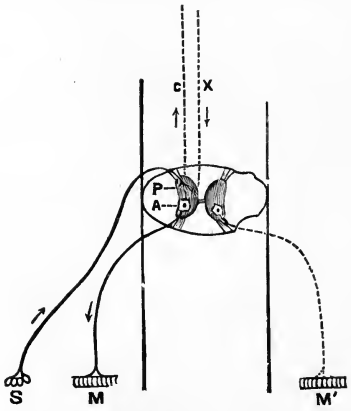


Fig. 13.

Diagram illustrating reflex action of spinal cord. *S* A sensory surface from which an impulse passes by a sensory nerve to the spinal cord by the posterior root of a spinal nerve. At *P* the nerve fibre breaks up and transmits the impulse to a nerve cell *A* in the anterior horn of grey matter; from *A* a motor impulse passes outwards along a motor nerve to the muscle *M*. Sometimes an impulse passes on to the other side of the cord, and then to a muscle *M* on the other side of the body. When the brain is concerned in an action, the passage of the impulse to that organ is indicated by the dotted line *C*, and the passage of an impulse from that organ by the dotted line *X*.

brain; and when it is crushed or injured those impressions commencing from below the injured part cannot be transmitted to the brain; yet by tickling that part unconscious movements take place in it, and these are called reflex. Movements which arise from sensory impulses and are carried out without consciousness are also reflex movements. In the case of an injury to the spinal cord in the middle of the back, tickling of the feet will produce a reflex movement of the toes, as the tickling sensation passes along the afferent nerve fibres to the posterior (back) part of the central portion of the spinal cord, in which the sensory cells are situated. They cannot pass up to the brain, owing to the injured cord, but the impression passes on to the motor cells in the front part of the cord, and from there an impulse is transmitted to the muscles of the feet through the efferent nerve fibres.

The simplest mechanism or structures necessary for a reflex act are (*a*) a sensory surface, (*b*) a sensory or afferent nerve, (*c*) a nerve cell or centre, (*d*) a motor or efferent nerve, (*e*) a muscle or gland.

The cerebral hemispheres (brain proper), especially the nerve cells in the grey matter on the outside of the brain, are the seat of conscious sensations, of perceptions, of intelligence, and of will. The lower parts of the brain are the seat for the subconscious, automatic, yet vital processes, of respiration and circulation, and also for many complex reflex actions, but consciousness, memory and judgment are stationed in the cerebral hemispheres alone.

Chemical Composition of the Body.—All substances are divided by chemists into elements and compounds, the former representing simple or indecomposable substances, and the latter compound ones, formed by the chemical union of two or more elements.

The elements found in the body are oxygen, nitrogen, hydrogen, carbon, sulphur, phosphorus, chlorine, sodium, potassium, calcium, magnesium, iron, manganese, silicon, fluorine and lithium. The first three occur both free and in combination, whilst the remainder are only present in compounds.

Oxygen (O) is an invisible gas that forms about one-fifth part of the atmosphere by volume. It supports combustion, and is absolutely necessary for animal life. It occurs free in the air passages of the lungs, and in the blood it forms a loose combination with the hæmoglobin of the red blood corpuscles, the latter giving up the oxygen to the tissues.

Nitrogen (N) is an invisible, inert gas forming about four-fifths of the atmosphere by volume. It occurs free in the air passages of the lungs, and is dissolved to a slight extent in the blood. In combination with other elements it forms the greater number of the substances of the body, many of these compounds being of very great importance.

Hydrogen (H) is a very light, invisible and combustible gas. A little free hydrogen is occasionally found in the intestines, arising from the fermentation of certain foods. In combination with other elements it is present in many compounds of the body.

Carbon (C) is a solid element existing in a variety of forms. Blacklead and diamonds are natural conditions of the element, whilst charcoal is an

artificial form. When carbon burns it unites with the oxygen of the air to form carbonic acid gas (CO_2). Carbon exists in a combined form in most animal and vegetable substances, and the oxidation or burning of these results in the formation of carbon dioxide (CO_2) as one of the products. Carbon does not exist free in the body.

Chemical compounds of the body.—These are divided into organic and inorganic compounds. Every separate living being, animal or vegetable, is sometimes termed an organism, and the various substances built up or produced by organisms which contained carbon were called organic substances, but as they can now be produced artificially we include in that term all carbon compounds, however produced, as fats, sugars, starches, and proteids. Substances obtained from the earth, that is, from the mineral kingdom, are called inorganic compounds, as clay, common salt, limestone, water, etc.

Plants, like animals, consist of living cells that are constantly building up living matter out of the food supplied to them, which in the case of plants consists of the simple inorganic substances found in the soil, and of the carbon dioxide in the air, from which they obtain the carbon they require. So plants live on simple inorganic materials obtained either from the soil or the air, and then convert them into those complex organic substances which form their tissues. On the other hand, man and other animals cannot convert inorganic materials, except water, into the living substances of the body, and so animals must feed on the organic substances formed by plants or supplied by the tissues of other animals that have lived on plants. The chief inorganic compounds found in the human body are water, carbon dioxide, sodium chloride and calcium carbonate and phosphate.

Water (H_2O) is a compound of the two elementary gases, hydrogen and oxygen. It is present in all the tissues, and forms two-thirds of the body weight. Though a little is produced in the body, yet it is nearly all derived from food and drink. The water acts as a solvent for the nutrient matter, makes certain tissues soft and flexible, and assists processes of secretion and excretion. It also serves for the regulation of the body heat, by evaporation from the lungs and skin.

Carbon dioxide (CO_2) commonly called carbonic acid gas, is formed continuously in the body by the oxidation of carbon, and so is present in all tissues, including blood, from which it is secreted in the lungs.

Hydrochloric acid (HCl) is a compound of hydrogen and chlorine, and exists in small quantities in the stomach, being produced by the cells lining that organ. It is of great service in digestion.

Sodium chloride (NaCl) is ordinary common salt, and exists in the blood and many other liquids of the body.

Calcium carbonate and phosphate are found chiefly in bone. Many other inorganic salts exist in the body, but only in very small quantities. When a body is cremated various compound gases, chiefly carbonic acid, ammonia and watery vapour, are formed and escape into the atmosphere, whilst the ash which remains is composed chiefly of the incombustible, inorganic salts.

The organic compounds of the body belong, for the most part, to three great groups—proteids, carbohydrates, and fats. The proteids are complex nitrogenous bodies containing carbon, hydrogen, oxygen, nitrogen and sulphur. The varieties of proteids are many, but they have one point in common, viz., that they contain nitrogen, and are the only class of food which do so. Tissues require nitrogen for growth and reparative processes, and hence proteids are often called tissue builders. They can also be used for fuel, being oxidised to produce H_2O, carbonic acid and urea, though the chief fuel ingredients of food are carbohydrates and fats. Proteids are most abundant in the lean meat of all animals, the white of an egg, and in such vegetables as peas and beans.

Carbohydrates are organic compounds of carbon, hydrogen and ogygen in which there is always the same proportion of hydrogen and oxygen as in water, viz., two atoms of hydrogen to one of oxygen. The substances known as starches and sugars belong to the carbohydrates, which in the body become oxidised, being converted into carbon dioxide and water, such changes generating heat. Fats are also organic compounds containing carbon, hydrogen and oxygen, but the oxygen is smaller in proportion to the hydrogen than in the carbohydrates. Fats and oils are found in the tissues of some animals, in milk and in certain seeds. The oxidation of fats is one of the chief sources of heat to the body, a given weight of fat producing more heat energy than the same weight of any other food stuff.

Proteids and carbohydrates are converted into soluble bodies by the stomach and small intestines, and then pass into the capillaries of the portal circulation, which convey them to the liver. Here a percentage of the carbohydrates is arrested and stored up in the liver cells, whilst the remainder undergoes combustion in the tissues, as likewise does most of the proteid material. The chief waste product of the latter is called urea, excreted principally by the kidneys.

Fats are absorbed into the intestinal lymphatics, called lacteals, which carry them into the blood stream, and the latter conveys them to the tissues, where they undergo slow oxidation, producing carbon dioxide and water.

The living body may be regarded as a machine, the fuel being the food which undergoes oxidation, producing heat and the energy for muscular and nervous labour. The food is not only an energy producer, but it also furnishes the materials for the repair of the waste that is continually going on, and during the early period of life it increases the size of the body and its organs. The body is not only a self repairing, but also a self constructing machine. It loses on an average about eight pounds per day in weight, made up as follows—

	Water.	Solids in solution.	Carbon dioxide gas.
From the lungs	12 oz.	— ..	26 ounces.
From the skin	24 "	.. ½ oz. salts. .	Small quantity in solution.
From the kidneys	56 "	.. 1½ " urea. ..	" " "
		1 " salts. ..	

In this daily loss the chief elements are carbon, nitrogen, hydrogen and oxygen. The carbon is lost chiefly in the carbon dioxide given off by the lungs, and the nitrogen disappears in the urea dissolved in the urine. There

are fifteen parts of carbon given off to one of nitrogen, about eight ounces of the former to half an ounce of the latter. It is evident that if a man is to keep his weight and to continue warm and active, fresh material must be taken into his system in order to repair the waste, and to restore, by oxidation, heat and other energy expended, whilst in the young body provision must be made for growth.

PATHOLOGY.

Pathology is the study of the body in disease, but all pathological changes are merely modified physiological ones, there being no essential difference between the two. Thus, we have seen that serous effusion from the capillaries into the tissues is an ordinary process of healthy nutrition, but that serum, in excess, causes dropsy. The exit of white corpuscles from the capillaries into the plasma is also a normal process, but white corpuscles in excess become the products of inflammation and suppuration (formation of pus). These gradations show how insidiously healthy processes pass into diseased ones.

Inflammation.—When a foreign body, either of a chemical or physical nature, is introduced into the tissues, certain changes are manifested, which represent the reaction of the system, or parts of it, against the injurious effects of irritants, whereby nature endeavours to destroy, counteract, or throw out what is noxious, and also strives to repair what has been injured, and to restore that which has been destroyed. These processes are called an inflammation, a beneficent action representing nature's efforts to expel or render innocuous foreign bodies.

The white corpuscles are the cells which chiefly attack and remove foreign bodies, and hence they are called the scavengers of the body, but their activity is largely dependent upon the presence or otherwise of certain complex chemical bodies in the blood plasma.

When an irritant is introduced into a tissue the neighbouring blood vessels dilate, so bringing an increased number of white blood corpuscles and serum into the area. The former are also produced in much greater quantities, and they, together with the serum, pass out of the walls of the capillaries into the tissue much more freely than usual, resulting in redness and swelling of the latter.

An inflammation of a tissue is accompanied by the following signs: Redness, heat, pain and swelling of the inflamed part, and these may be detected externally when the inflammation is not situated too deeply in the body.

The redness and swelling are due to the dilated condition of the blood vessels, and to the increased outflow of plasma and white blood cells from the capillaries into the tissue. The degree of swelling in an inflammation varies directly with the density and the vascularity (number of blood vessels) of the tissue; for instance, in loose vascular connective tissue, such as the subconjunctiva, the swelling may be so great as to partially hide and cover the cornea, whilst in denser vascular connective tissue, like the cornea, the swelling is so slight as to cause merely a minute bulging over the inflamed area.

The increased heat arises from the greater cellular activity, and the pain from the increased pressure on the nerves by the over distended tissue.

In inflammation the first appreciable change is hyperæmia—the blood vessels dilating and containing an excessive amount of blood; later the white blood corpuscles occupy the peripheral, and the red cells the central portion of the capillaries, and later still the white corpuscles and serum pass freely out into the surrounding tissue, causing the latter to appear cloudy and swollen. If the inflammation goes on still further, the red corpuscles also gradually ooze through the vessel wall, the circulation of the red corpuscles in the centre of the vessel ceasing, and a complete stagnation of the blood in the vessels follows, resulting in the formation of a blood clot, and later in death of that part.

A more common termination is recovery from inflammation, the blood vessels gradually becoming less dilated and passing into their normal condition, the exuded colourless corpuscles either passing back again into the capillaries or breaking up into a granular material, and, together with the increased serum, passing out through the lymphatics into the general blood stream again. An inflammation is merely an exaggeration of the normal nutritive exchanges between the blood capillaries and the affected tissue, and all degrees of severity and extent are encountered, being localised merely to a small area, or involving one or many organs. If the irritant be only mild, recovery without any permanent tissue changes results, but if severe, recovery only takes place at the expense of destruction of tissue, the latter being transformed into pus (matter).

Though any foreign body introduced into the tissues acts as an irritant, and causes some inflammatory reaction, yet, if that body contain no microbes, its presence is tolerated by the tissues, the latter enclosing it in a capsule. This foreign body, if small, may become gradually absorbed, or, if of dense structure, may remain encapsuled in the tissues. If very large it may be slowly extruded from the body by the tissues. The innocuousness or otherwise of a foreign body in the system does not then depend so much upon its size or density as upon the presence of microbes.

Microbes.—These are very minute living vegetable organisms, consisting of

Fig. 14.

Pneumococci. Magnified 1,000 diameters.

a mass of protoplasm enclosed in an envelope, and are classified, according to their shapes and their reactions to various staining reagents, into numerous divisions, but such classification is necessarily rather crude. They are very small, varying from one micro-millimetre (1/1000th part of a millimetre) in length to a few micro-millimetres.

When circular in shape they are called *cocci*, and when rod shaped, *bacilli*, whilst others are more filamentous and are called *spirillæ*.

These divisions are very broad, and include hundreds of different kinds of organisms in each division.

The commonest forms of cocci are perhaps the *staphylococci*, which arrange themselves in bunches like grapes; the *streptococci*, which arrange themselves in lines; and the *gonococci* and *pneumococci*, which arrange themselves in pairs. A picture of the latter is shown, the microbes being taken from the conjunctival sac of a patient suffering from corneal ulcer.

Fig. 15.
Diplobacilli. Magnified 1,000 diameters.

Bacilli consist of many different varieties, a common one being the tubercle bacillus. This rarely attacks the eye, which is more often attacked by a Kock Weeks bacillus, causing the pink eye so commonly seen in children. The *diplobacilli*, so called because of being arranged in pairs, placed end to end, cause angular conjunctivitis (Chapter III.).

These living organisms play a great part in the work of nature, as they break up into more simple combinations the complex molecules of the organic substances which form the bodies of plants and animals, or which are excreted by them. In a few cases we know some of the stages of disintegration, but mostly we are only familiar with general principles and results. Thus the souring of milk and the ripening of cream and cheese are all due to bacteria. Bacteria are also capable of giving rise to poisonous substances (toxins) within the animal body, and also in artificial media. These are of a very complex character, very little of their actual nature being known, but each kind of organism produces a specific toxin. It is the

latter which is so inimical to the tissues of the body, and the rate of production depends upon whether the conditions are favourable or otherwise to the growth of the organism. The toxins also exercise a prejudicial influence on the organism itself, the latter being frequently killed by the toxin.

Bacteria are human-like in their sensitiveness to outside influences, their vitality being increased or decreased by unsuitable temperature and food. Some prefer warmth, others cold; some thrive on air, others without it, and some grow better on such food as potatoes, others on jellies, etc., and this artificial food we term a culture medium. Excessive heat and cold kill them, as do various chemical agents called antiseptics. Antiseptics are not able to destroy microbes present in the body, as the vitality of the organism is generally greater than that of the cell, and the antiseptic would kill the cell whilst only weakening the organism. The latter rapidly becomes revitalised, the dead cell being an excellent food tonic for the microbe. Antiseptics have, therefore, for this purpose, fallen into desuetude.

An aseptic body is one which contains no organisms, and in surgical operations everything is made aseptic. Though bacteria are necessary to animal life, some of them, as above stated, are prejudicial, waging war upon mankind, and it is with these latter organisms that we are mostly concerned. Many forms of microbes are present in the air, and are carried by it into all the cavities of the body communicating with the external air, as the nose (and its accessory cavities), the bronchi and lungs. The food we partake of carries organisms into the stomach and intestines, many of them being of great assistance in digestion. These mostly only live on dead matter, such as the food, breaking it up into simpler bodies. They are then called saprophytes, but there are also present other bacteria which can attack living animals or plants under certain conditions. These are called parasitic bacteria, and they are commonly found on the surface of the skin and the mucous membrane lining the cavities of the lungs, intestines, etc., but they are not present in the tissues, the epithelial cells being the first of nature's bulwarks protecting the body against the attack of these organisms. If the organism be very virulent, or the epithelial cell be debilitated or injured, the microbe may gain an entrance into the tissue. We will now consider the results of such an invasion.

The blood vessels of the affected part become dilated, and more lymph and leucocytes pass into that area, the phenomena of inflammation, as previously described, beginning. The leucocytes attack the invading agencies, and, if victorious, the latter are eaten up, and the tissues return to the normal again, but when defeated the tissue cells and leucocytes are killed, forming, together with the toxines and the disabled microbes, a whitish fluid called pus or matter. Nature brings up more leucocytes to resist the further encroachment of the victorious microbes into the tissues, and she generally succeeds in forming barricades, consisting of young white blood corpuscles, which surround and cut off the infected area from the general system. This limitation of the affected area leads to the formation of a localised collection of pus called an abscess, which gradually burrows to the surface and bursts, so discharging its contents, and preventing the further absorption

into the system of the toxins which are produced in the abscess cavity. It is advisable for the surgeon to expedite the liberation of the pus by incising the abscess, thus preventing the absorption by the body of the toxins. When the organism overcomes these barriers erected by nature death of the individual takes place. The ultimate result of the contest between the contending forces of the body and of the microbes depends largely upon the degree of virulence of the latter, and the degree of activity of the white cells of the patient, which, in turn, is largely dependent upon the presence or absence in the blood serum of certain bodies called opsonins, etc., that stimulate and increase the combative power of the white cells. These bodies are distinct and specific for each kind of microbe, and it is the toxins of the latter which incite nature to produce them.

When an abscess or severe inflammation occurs in a special tissue, as muscle, the retina, etc., the affected area is not replaced by that, but by ordinary fibrous tissue, and so the function of that area is lost, hence the importance of cutting short an inflammatory attack in a specialised tissue.

Catarrhal inflammation is a term applied to mucous membranes such as the conjunctiva, etc., where the inflammatory affection consists only in a more congested (reddened) condition of the part, together with the production of an increased quantity of mucus by the mucous glands, the latter being present in great numbers on mucous surfaces.

The toxins produced by the bacteria at the inflamed area pass into the general blood stream, and may cause an inflammation of another part of the system. For instance, the ciliary body is frequently inflamed (cyclitis) by the toxins generated by the organisms which frequently lodge between the gums and the teeth, and the treatment of that cyclitis consists in the extraction of those teeth.

Tubercle or consumption is due to a special bacillus, which, though commonly found in the lung, may attack any portion of the body, although it rarely invades the eye. The resulting pus is frequently caseous (like cheese) in appearance. Syphilis is an infectious disease caused by an organism which belongs to a higher species of microbe called the spirochita pallida. It may be acquired by direct communication with an infected person, or it may be inherited from infected parents. Many eye lesions are due to this disease, the inherited variety causing a deep inflammation of the cornea (so called interstitial keratitis) and also affections of the fundus. The acquired variety frequently affects the iris, causing iritis; retinitis and choroiditis are also common consequences of this affection.

Ulceration.—This is essentially of the same nature as the process of suppuration, only that the purulent discharge, instead of collecting in a closed cavity and forming an abscess, at once escapes upon the surface. There is thus a loss of surface epithelium at the part, which appears as an open wound or sore. In the eye a small ulcer on the cornea is not infrequent, and may be caused by a foreign body carried in by the air, or it may be due to the attack of microbes.

DEGENERATION.—When a tissue is insufficiently nourished it degenerates, losing firstly its highest function. This process is commonly observed in the cornea of old people, appearing as an opaque whitish area (arcus senilis) concentric with the corneal margin. The transparent corneal tissue becomes changed into an opaque tissue, owing to interference with nutrition. Degeneration may affect any tissue in the body, but the higher developed the tissue the greater the tendency to degeneration.

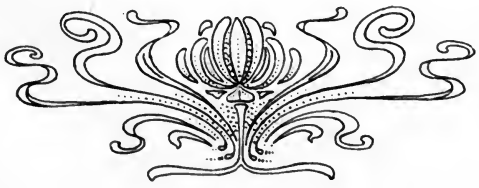
TUMOR.—This is a localised swelling, composed of newly-formed tissue, which fulfils no physiological function. Tumors tend to grow continuously, quite independently of the growth of the body, and there is no natural termination to this.

For clinical purposes tumors are arbitrarily divided into two great classes—the innocent and the malignant.

The innocent tumor may consist of any of the normal tissues of the body, as bone, muscle, fibrous tissue, etc. They grow slowly, and are generally surrounded by a fibrous capsule.

They differ from malignant tumors by the fact that they do not invade or spread to a different portion of the body, but they may grow to quite a large size, pushing aside and compressing adjacent parts. Malignant tumors, on the other hand, show a marked departure from the normal structure and arrangement of the tissues of the body. They tend to invade the surrounding tissue by sending out prolongations or offshoots into it, and they frequently spread to other parts, being carried either by the blood stream or the lymphatics, and eventually destroying life.

Early operation offers the only chance of a complete cure, but the results of such depend largely upon the degree or otherwise of the malignancy of the growth and also upon its situation.



EXAMINATION OF THE EYE.

Chapter II.

The affections of the eye are of such a nature that their salient features are very liable to be overlooked, unless great care is exercised, and too much significance cannot be attached to the importance of habitually examining the eye in a methodical manner.

Normal visual acuity cannot be accepted as any guarantee against the presence of disease in the eye, and any improvement in vision obtained by use of the pinhole disc is evidence only of some refractive error, but does not exclude the possibility of disease in an ametropic eye—a not unusual occurrence. These cases show the importance of not accepting a subjective standard, and additional emphasis is given to this from the fact that the subjective symptoms in ametropia and in pathological conditions are commonly alike. The method to be pursued in an examination of the eye is one which will enable us to correct the refractive error, and to exclude any possible pathological change in as expeditious a manner as is consistent with thorough examination. The following method, almost universally practised, is that which is most advisable for optical students to adopt:—

1. The presence and appearance of any gross pathological condition should be noted whilst the patient is stating his symptoms.

2. Visual acuity to be taken.

3. The transparency of the media, the healthiness of the fundus, and the refractive error have to be determined, and for these purposes the patient is now taken into the dark room, and the eyes examined:

   (*a*) *By focal illumination*, especially with the view of detecting slight opacities in the cornea and lens. The pattern of the iris must be noted, and the pupillary actions tested.

   (*b*) *By transmitted light*, using preferably a plane mirror and a low illumination; the transparency, or otherwise, of the lens and vitreous being further determined.

   (*c*) *By retinoscopy.*

   (*d*) *By the indirect ophthalmoscopic method*, or this may be omitted, and only the direct method used.

4. The objective results are now confirmed by subjective testing; or the keratometer may be used prior to such testing.

5. The muscular sense, the field of vision, and the light sense may be examined when these are expected to throw any light on the cause of the patient's symptoms, but investigation of the muscular balance is advisable in every case.

The examination of the various parts of the eye is given below in more detail, but it is only necessary to investigate them with such minuteness when the patient's symptoms point to a possible lesion. For instance, with muscæ volitantes the vitreous must be carefully searched, in order to exclude pathological opacities, or, if lachrymation be complained of, diseased conditions of the lachrymal apparatus would be excluded as explained in Chapter IV.

Whilst listening to the statement of the patient's symptoms, the observer must make a rapid survey of the patient's face, brow and orbits, noting especially the position, direction and size of the globes. If there be a suspicion of a deviation of one eye, it should be roughly confirmed by directing the patient to look steadily at the observer's finger, held in the middle line, about an arm's length from him. The observer's other hand is now placed in front of one eye, say the left, of the patient, and if the latter's right eye has been fixing the observer's finger, no movement of it will be detected; but if the eye had been deviated inwards a little, an outward movement would be made in order to fix the finger, or if the eye were deviated outwards an inward movement would be detected.

Also, on the observer withdrawing his hand from the patient's left eye, no movement will be discernible in that eye, if the patient has normal muscular equilibrium (orthophoria), but if esophoria be present, the eye will be seen to move quickly out in order to fix the observer's finger, or an inward movement will be detected if exophoria be present. Testing each eye separately, the elimination of the grosser muscular anomalies can be accomplished in a few moments by this procedure.

The position and margins of the lids should be noted, and also the region of the tear sac, when lachrymation is complained of, and if simple inspection discloses no alteration, pressure with the finger over the sac will cause its contents to exude through the puncta.

Examination by Focal Illumination.—The lamp is placed at some distance in front and slightly to the side of the patient, and the light is condensed by means of a large lens (about + 10 to + 20 D), and brought to a focus on the parts to be examined. Fine details may be looked for by means of a corneal magnifier. The eye, as far back as the anterior surface of the lens, can be examined by focal illumination, and opacities in the cornea or in the anterior part of the lens appear white. By focal illumination opacities in the cornea can be recognised which are perceptible in no other way.

The anterior chamber should be observed with regard to its depth; in elderly people with glaucomatous tendencies it is often abnormally shallow, whilst in myopic individuals the chamber is deeper than in the normal eye. Irregularity in depth is one of the signs of a dislocated lens.

The iris should be examined for distinctiveness or otherwise of its markings, and any evidence of old or present iritis noted.

The pupillary reaction to light (see Chap. VII.) should be tested, by first concentrating the illumination upon it, and then withdrawing it; also the other pupil should react consensually. The pupillary reaction to convergence and accommodation may be tested, as contraction occurs with convergence. The shape, colour and position of the pupil should also be noted.

Fig. 16.
Focal examination.

The anterior surface of the lens can be examined by focal illumination, when opacities will appear white.

The above examination only takes a few seconds, but the points must be observed in a methodical manner.

The transparency of the refracting media is now further tested by projecting light into the eye from a distance of about one metre, using preferably the plane mirror of the ophthalmoscope, with a low illumination, which should come from behind the patient, being either above or to one side of him.

The pupillary area appears red by transmitted light, and this is known as the fundus reflex. Any opacity in the media appears as a black body upon the red background, and its position can be determined by its apparent displacement upon movement of the eyeball. The fundus reflex appears to be situated in the pupillary area, and opacities in front of this plane appear to move with the eye by transmitted light, and the further forward they are situated the quicker the movement, so that an opacity stationed in the upper portion of the cornea appears, when the eye looks down, to be on the lower part. Opacities behind the plane of the pupil appear to move in the opposite direction to the eye, so that a posterior lenticular opacity appears to move upward as the eye looks down.

An opacity in the plane of the pupil, as one upon the anterior surface of the lens, does not apparently change its relative position. On movement of the eyeball, if stationed on the centre of the pupil, when the patient looks straight ahead, it still appears to be in the centre when the patient looks up, down, in or out.

Opacities in the solid media, cornea and lens move only with the eyeball, but when stationed in the vitreous they move independently of the eyeball, as will be seen by directing the patient to quickly look up and down, and then straight ahead, when the opacities will be descried gradually sinking down.

Where further details of an opacity or of the media are desired, they can be obtained by substituting high convex lenses behind the small ophthalmoscopic mirror, and approaching as near to the eye as possible, as if for the direct ophthalmoscopic examination. The cornea may be seen with a + 20 to + 30 D, the iris and anterior capsule of lens with a +15 to + 20 D, the posterior surface of lens with a + 10 D, and the anterior portion of the vitreous with a + 8 D; the deeper the opacity be situated in the vitreous, the less the strength of the lens which will focus it.

The retinoscopic examination should now be conducted, but as this book is chiefly intended to treat of diseased conditions, information upon the use of the instrument must be sought elsewhere.

Ophthalmoscopic Examination.—Helmholtz introduced the first ophthalmoscope, and prior to that it was thought that the blackness of the pupil lay in the absorption of light rays by the choroid. Helmholtz, however, demonstrated that the rays of light entering the pupil are not all absorbed, but that the greater number are reflected back again through the pupillary aperture. These cannot ordinarily be perceived, as the observer, in attempting to intercept them, shuts out the source of light by the interposition of his face. Helmholtz overcame this difficulty by reflecting the light, placed to the side of the patient, into the eye by a mirror in which a central aperture was placed, and to which the observing eye is applied. No details of the fundus could be thus obtained, but only a red reflex, and this difficulty was overcome by the interposition of a strong convex lens (about +12 D) between the mirror and the observed eye, by means of which all the rays reflected from the retina could be gathered into a single focus, and thence diverging, could easily be brought to a second focus in the observer's eye, the latter thus perceiving not a direct image of the fundus, but an inverted aerial one formed by the convex lens, somewhere between it and the observer's eye.

Later, another method of solving the difficulty was discovered—by approximating the mirror to the patient's eye, and placing before the sight hole a lens of sufficient curvature to neutralise the patient's refraction, and, if ametropic, that of the surgeon as well. By this means all the emerging rays would naturally come to a focus upon the surgeon's retina. This was effected by the invention of a magazine of lenses of varying strength, which could be rotated in sequence before the sight hole until the suitable lens was obtained. By tilting the mirror, and providing an arrangement by which it could be rotated at will, the necessary amount of illumination

was obtained. This method is called the direct method of examination, and an erect image of the fundus is obtained; whilst the other is called the indirect method, the image being an inverted one, the upper corresponding to the true lower, and the right to the true left side.

The image obtained by the ophthalmoscope is considerably magnified, but much more so with the direct (about 15 diameters) than with the indirect (about 5 diameters). In both, however, the magnification is influenced to some extent by the refraction of the eye, being greatest in indirect examination of high hypermetropia, and least in high myopia, whilst it is the reverse with the direct method, the largest image being obtained in myopia, and the smallest in hypermetropia.

Each of these two methods has its advantages. By direct examination there is a large magnification, the estimation or confirmation of the refraction being possible at the same time as the fundus is examined. Elevations and depressions can not only be appreciated (as also in the indirect method), but can be directly measured, and any opacities in the different refractive media can be located and examined.

The advantages of the indirect method are that it gives a more general view of the fundus, and when the media are hazy it is possible to get a view when one cannot do so by direct examination. In very high myopia the direct examination is rather difficult, whilst it is quite easy by the indirect.

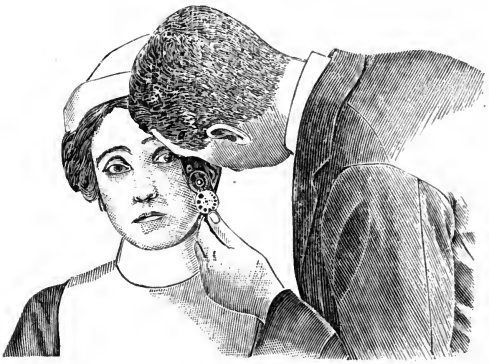


Fig. 17.

Direct ophthalmoscopic examination.

Note observer is standing to the side of patient, and that the latter's face is not obscured by that of the observer.

The lamp is behind the observer.

Both methods should be learned, but the direct method will prove by far the most useful in practice. It is advantageous for beginners to practise on a dilated pupil, but when once thoroughly conversant with the instrument a mydriatic is very rarely necessary. Good illumination is essential, and preferably the room should be darkened. The light is generally fitted on a movable arm, and placed to one side of, and slightly behind, the patient, about the level of his ear, whilst the patient is sitting down. It is more convenient to examine young children standing.

In emmetropia the rays emerge from the patient's eye in a parallel beam, and so are focussed upon the observer's retina (provided he is emmetropic or is wearing his full correction) without any accommodative effort, but if accommodation be used, the rays will be brought to a focus anteriorly to the observer's retina, and only a blurred image of the fundus will be seen.

In hyperopia the rays emerge divergent, and the observer has either to accommodate in order to see the fundus distinctly, or else to substitute behind the sight hole a convex lens equivalent in strength to the patient's refractive error.

In myopia the rays emerge convergent, and it is necessary for the observer to place a concave lens, corresponding to the refractive error, before the sight hole, in order to see the fundus clearly.

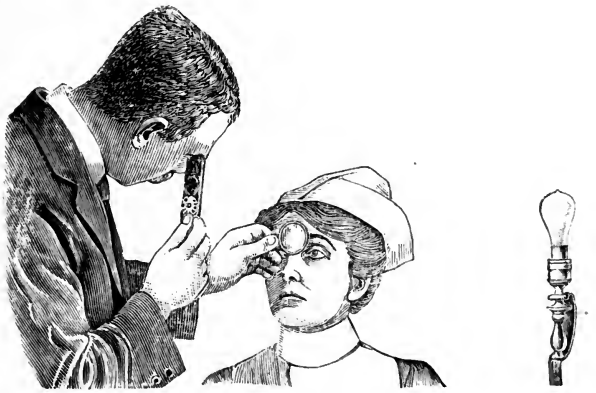


Fig. 18.

Indirect ophthalmoscopic examination.

In the indirect method the patient's right eye should be examined by the observer's right eye, and his left by the left eye, or the observer may use the same eye for both. Seated in front of the patient, at a distance rather less than an arm's length, the observer, holding the mirror close to his eyes, reflects the rays from the lamp into the patient's pupil, illuminating it by the red glare, known as the "fundus reflex." Either a plane or a slightly concave mirror may be used, and it is preferable to put up a + 3 D behind the sight hole. The next step is to locate the disc, which, owing to its colour, is the most conspicuous object, and to see this the patient must be directed to look a little inwards, towards the observer's opposite ear; that is, the observer's right ear in examination of the right eye, and *vice versa*. A slightly whitish reflex is generally seen, and then the object lens (about + 12 D), held between the forefinger and thumb of the other hand, is placed in front of the patient's eye, about two inches from it, and steadied by resting the tips of one or two disengaged fingers against the patient's brow.

The convex lens is now removed just far enough from the patient's eye to cause the margin of the pupil to disappear out of the observer's field of vision, and the latter then ceases to look into the eye, but fixes his gaze upon the convex glass, when the inverted image of the fundus should at once become visible, appearing to be situated in the convex lens, though it really is in the air somewhat on this side of the lens. By moving his own head a little backwards and forwards, or by slightly altering the position of the lens, approximating, withdrawing, or slightly tilting it, the observer will soon succeed in seeing an image of the optic disc and retina. This slight shifting of the head and lens can only be learned by practice, and the beginner, at first, will be much troubled by a reflection of the lamp from the surface of the cornea, which he will soon learn to disregard. It is preferable to use quite a large convex lens (2inch diameter), so obtaining a larger field, and rendering the corneal reflex less troublesome. The observer, if ametropic, should either wear his correction, or have it inserted behind the mirror.

In the direct method the light is arranged at about the level of the patient's ear, slightly to one side and behind it, and the observer sits or stands at the side of the patient, using the right eye for the patient's right, and the left for the left. The small tilted mirror of the ophthalmoscope is used, and is so arranged that the apex or non-tilted edge points towards the observer's nose; an imaginary line running from the centre of the tilted edge to the centre of the non-tilted edge (apex) should be in the horizontal plane. The upper end of the ophthalmoscope rests just underneath the observer's eyebrow, and the difficulty which beginners often experience in well illuminating the pupil is most frequently due to an unconscious slight tilting of the ophthalmoscope, and, as a result, they are looking obliquely through the sight hole, so cutting off much of the illumination.

In overcoming the difficulties of illumination, beginners will find it most useful to practise throwing the light at will to any part, such as the back of one's hand. Having obtained a good reflex, the observer must approach as close to the patient as possible, especially with myopes. In order to bring the disc into view, the patient is directed to look a little inwards (about 15 degrees), and the observer, in order to relax his accommodation, should always imagine that he is looking through the patient's head into infinity. If no details of the fundus can be detected, even though the red glare is distinct, higher concave lenses are put up until the fundus is clearly seen. At first the observer, always unconsciously, exercises his accommodation—a fault which time and practice rectify. After the disc and vessels have been observed, the macula is examined by asking the patient, making a movement of the eye only, to look directly into the observer's mirror. This area is the most difficult part of the fundus to see, owing to the greater contraction of the pupil which takes place when light is concentrated on it, and also to the absence of any distinctive markings in this region. Confusion is caused also by the troublesome corneal reflex being more noticeable. The latter difficulty can be partly obviated by looking through, not the centre, but either the inner or outer side of the cornea.

The other parts of the fundus are afterwards examined.

The difficulties with direct examination are chiefly caused by:—

(1) *Illumination*, owing to the tendency to look obliquely through the sight hole.

(2) *Accommodation.*—The observer must relax his accommodation—a habit acquired by practice only. It is advisable always to assiduously use convex lenses of increasing strength, or concave lenses of diminishing strength, behind the mirror, endeavouring with each increase or decrease to see clearly the details of the fundus. Though the beginner will find it difficult at first to keep both eyes open during the examination, yet he must always strive to do so, this being most helpful in preventing accommodative effort.

(3) *The reflection of the lamp from the surface of the cornea.*—This is most annoying at first, but practice, and looking through the cornea a little to one or other side of its centre, quickly overcome this difficulty.

(4) *Very dark fundi and high myopes.*—These present greater difficulties than usual, and in the latter cases it is essential for the observer to approach as closely as possible to the patient's eye, practically touching the lashes.

The attainment of proficiency in the direct method of examination should be early acquired, as it will prove of much more practical value than the indirect, owing to the larger magnification obtained and to the confirmation of the retinoscopic examination it affords.

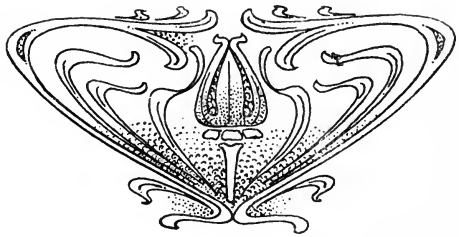
In estimating the refractive error of the patient it is necessary for the observer to relax his accommodation, and, if ametropic, either to wear his correction or to subtract the amount of his ametropia from the total result obtained. In the direct examination patients more completely relax their accommodation than in any other objective examination, and so it affords a most valuable guide in suspected cases of ciliary spasm.

Although, theoretically, the macula should be taken in estimating the refractive error, yet the absence of any distinctive vessels in that region makes it preferable to fix the smaller ones leaving the disc. The observer fixes one of the vessels, and, while doing so, rotates convex or concave lenses, as the case may be, before the sight hole of the mirror, until he has found the highest convex or lowest concave lens with which the disc and its vessels are plainly seen. This lens, after the subtraction of his own refractive error, will represent the degree of H or M respectively.

It is not a difficult matter to estimate the difference of refraction in the vertical and horizontal meridians, as a vessel running vertically gives us the refraction in the horizontal meridian and *vice versa*, and the difference between the two represents the astigmatic error. Oblique astigmatism presents greater difficulties, owing frequently to the absence of vessels in the plane corresponding to the astigmatism.

In determining the refractive error, the observer's mirror must be a plane one, and he should approach closely to the lashes of the patient. It is more convenient to have both a plane and a slightly concave mirror fitted for direct ophthalmoscopy, as the latter brings out the macula more distinctly; but the disadvantage of using both types of mirror lies in the slight difference of colour noted in the fundus, the concave causing it to appear a little lighter.

Differences in level can be detected and calculated, a depression (cupping) requiring a lens of less power, and an elevation one of greater power, than that needed for the surrounding fundus, but this is not so sensitive a test as that of parallactic displacement. A difference of 3 D is equivalent to an alteration in level of 1 mm.



THE EYELIDS AND CONJUNCTIVA.

Chapter III.

ANATOMY OF THE LIDS.

The lids are, in origin, folds of the external skin, which push their way over the eyeball to cover and protect it. The boundaries of the upper lid are formed by the eyebrow, but the lower lid passes, without any sharp line of demarcation, into the cheek.

Of the two eyelids, the upper is the larger, the deeper and the more movable. The skin covering the lids is very thin, and is only loosely attached to the tarsus underneath, so that it can be moved independently, thus wrinkling readily when the eyes are opened, and becoming stretched when they are closed. Because of the ease with which the skin can be displaced, cicatrices, either in the lids or in their vicinity, readily distort them, so producing ectropion, or entropion. There is no fat in the tissue beneath the skin, and this laxity of the subcutaneous tissue is favourable to the accumulation either of blood—ecchymosis, noticeable in a contused eye—or of fluid—seen in kidney disease. In the neighbourhood of the free border of the lid, the skin is firmly united to the tarsus.

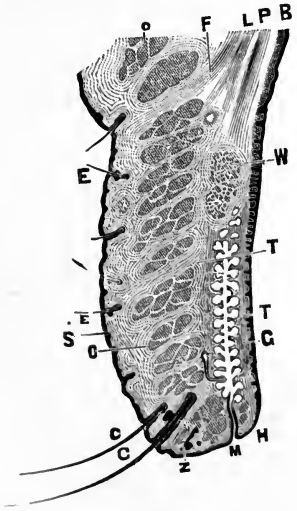


Fig. 19.

Perpendicular section through the upper lid.

CCC Eyelashes. *Z* Sebaceous glands opening into the follicle of the cilia. *EE* Fine hairs on skin surface of lid. *T* Tarsal cartilage. *M* Opening of Meibomian glands (*G*). *L* Levator palpebræ superioris and *F* Portion of the latter going forwards to be inserted into the skin. *P* Muller's muscle. *O* Orbicularis muscle. *B* & *H* Conjunctiva. *S* Skin.

The aperture between the lids is called the interpalpebral aperture or fissure, and the mean width of it varies with the individual. The shape and width of this aperture has the greatest influence upon the expression of an eye:—An eye popularly called small bears no reference to the size of the eyeball, but only to the width of the palpebral aperture. Eyes which are reputed to be large and beautiful are really only those with a wide palpebral fissure.

In all cases a small arc of the cornea is covered by the upper lid, but the upper level of the lower lid varies a great deal, perhaps not quite or only just reaching the corneal limbus, or even extending on to a portion of the cornea.

Each eyelid consists of the following structures from before backwards:

(1) Skin.—This is thin and delicate, devoid of subcutaneous fat, and connected with subjacent structures by loose tissue.

(2) Palpebral Portion of the Orbicularis Muscle.—A fine layer of arching fibres, which are inserted into the internal and external tarsal ligaments. Its function is to firmly close the lid. In the upper lid is also found the levator palpebræ superioris, which raises the lid.

(3) Tarsus.—This consists of fibro cartilage, and forms the chief framework of the lids. The upper is the larger of the two, and inserted into its upper margin is the levator palpebræ superioris, which is also continued over the surface of the tarsus. Associated with this muscle is a small layer of unstriped muscle, called Muller's muscle, which assists the levator in the elevation of the lid. Each tarsus is connected to the orbital arch by a strong band of tissue named the septum orbitale, the upper one being much stronger than the lower. Both externally and internally the tarsi are attached to the adjacent bone by fibres called the external and internal tarsal ligaments. The internal tarsal ligament, or tendo oculi, as it is often called, is much the stronger and more defined of the two, and it can be distinctly felt when the eye is turned strongly outwards. It is an important guide, for beneath it lies the lachrymal sac.

(4) Meibomian Glands.—These are modified sebaceous glands, and are placed at right angles to the free margins of the lid, on the posterior border of which they open. They lie imbedded in the posterior or conjunctival surface of the lid, and can sometimes be seen, on everting the upper lid, as fine yellow lines arranged in a radiating manner. These glands sometimes become blocked, forming meibomian cysts.

(5) Palpebral Conjunctiva.—This is closely adherent to the tarsus.

The free margin of a lid is flattened, and along its anterior border are placed the cilia or eyelashes, which are grouped in two or three rows. The upper ones are thicker, larger and more curved than the lower. Around the insertion of the cilia into the skin are placed small sebaceous glands, which secrete an oily material for lubricating purposes. When these little glands become inflamed, the condition is popularly called a stye.

On the posterior border of the free margin of the lid, the orifices of the meibomian glands are situated.

The points of meeting of the two lids are called the commissures or canthi. The external is well defined and angular, but the internal is rounded and elongated.

On either lid, near the inner canthus, and situated on a papilla, is placed a minute opening. This is called the punctum lachrymale, and it allows the tears to escape into the tear duct.

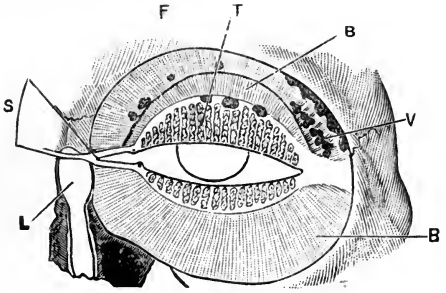


Fig. 20.

The skin and muscular fibres of the orbicularis have been removed from the lids and the parts surrounding them, thus exposing the tarsal cartilage and the septum orbitale, which connects the cartilage both above and below with the neighbouring bone.

T Tarsal cartilage. *B* Septum orbitale. *V* Lachrymal gland. *S* Internal tarsal ligament which lies just in front of (*L*) Lachrymal sac. *F* Represents the surrounding bone.

Movements of the Lids.—In opening the eye, the upper lid is raised by the levator palpebræ superioris, whilst the lower sinks a little by its own weight. Muller's muscle also assists the levator in raising the lid, and this muscle, being supplied by the sympathetic nerves, is occasionally paralysed, whilst the levator is unaffected, and then we note a slight drooping of the upper lid, together with a slight dilatation of the pupil (the dilator pupillæ being also supplied by the sympathetic).

In moderate closure of the eyes the upper lid sinks by its own weight and the lower lid is slightly raised by the orbicularis muscle. The free borders of the lid do not come in contact throughout their whole extent at once, but the closure commences at the external canthus, and runs successively to the inner canthus. This action propels the tears from the outer canthus inwards towards the puncta, from whence they escape into the nose. In sleep the lids are closed, and the eyeball rolls upwards.

Tight closure of the lid is effected by strong contraction of the orbicularis muscle. Winking, though it may be voluntary, yet generally results through reflex action, as when there is a foreign body or a sense of dryness in the eye. Winking covers the surface of the eyeball with a thin layer of tears, which remove dust from the eye and prevent dryness. It also drives the lachrymal fluid into the puncta. Interference with winking will cause epiphora (flowing of tears over the border of the lid on to the cheek), and the cornea would tend to become inflamed, owing to the collection of dust upon it. The levator palpebræ superioris, which raises the upper lid, is supplied by the facial or seventh nerve, and the orbicularis, which closes the eye, is supplied by the third nerve.

DISEASES OF THE LIDS.

Hyperæmia, or increased redness of the margins of the lids, is a frequent concomitant of refractive errors, of an irregular mode of life, etc. Persons of light complexion and blonde or reddish hair are particularly susceptible, and in such individuals the condition may last more or less all their life, in spite of both general and local treatment. Treatment consists in the correction of the refractive error and the enforcement of a regular mode of life. The eschewment of stimulating foods, as tea, coffee, stimulants, tobacco and red meat, is also advisable. Local treatment is as in blepharitis.

Blepharitis.—Inflammation of the border of the lids—so-called blepharitis—appears under two forms : blepharitis squamosa, and blepharitis ulcerosa.

Blepharitis squamosa.—In this condition the skin between and around the lashes is covered with small white or gray scales, appearing as if bran had been scattered over it. The scales are easily removed by simple washing, and beneath them the skin is found to be red, but not ulcerated. Frequently the cilia or lashes fall out, but, as the hair follicles are not destroyed, they afterwards grow again.

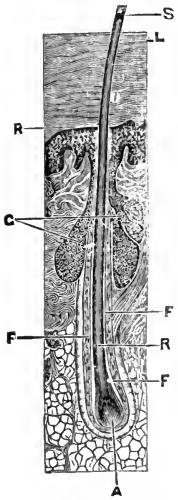


Fig. 21.

Vertical section of skin, showing root of hair and follicle.

S Stem of hair. *L* Skin level. *R* Root of hair. *A* Apex of root. *F* Hair follicle. *G* Sebaceus glands, which secrete oil for the hair.

Blepharitis ulcerosa.—In this form the border of the lids is covered with yellowish crusts, on removal of which the skin appears red, and around the hair follicle—that is, where the cilium is inserted into the skin—a little pus is seen, or a slight yellowish elevation, or the latter may have ruptured and the pus escaped, when a slight ulcer is revealed.

This condition is due to a microbe attacking the hair follicle, producing inflammation, followed by the formation of a little pus, and later by destruction of the follicle. The cilium, as in squamosa, falls out, but it does not grow again, the root of the hair (the follicle) having been destroyed. One follicle after another is attacked, until perhaps the whole of the lashes are destroyed.

Hairs upon any portion of the body consist of a root, the part imbedded in the skin, and the stem, the projecting part. The term root is really a misnomer, as it is not the part from which the hair grows. When we epilate a hair, including the so-called root, another grows, the reason being that the real root of a hair is the hair follicle. This consists of cells lining the so-called root, and from these a hair grows. The follicle remains intact when a hair is epilated. Destruction of a hair follicle not only results in the falling out of that hair, but no further growth can take place.

In blepharitis ulcerosa the microbe infects the hair follicle, so destroying and preventing the growth of a new lash, and this factor makes it a much more serious disease than blepharitis squamosa, in which the follicle remains intact.

When blepharitis has been present for some time, many of the following permanent changes are produced in the conjunctiva and the lids—

(*a*) Chronic conjunctival catarrh is constantly present.

(*b*) Increased thickness of the margins of the lids takes place and causes drooping of the lid (tylosis).

(*c*) In blepharitis ulcerosa the whole of the lashes may be destroyed, and there remains upon the border of the lid perhaps only a few small downy hairs. This condition is called madarosis.

(*d*) Changes in the position of the lids may take place, either becoming inverted (entropion) or everted (ectropion).

For treatment, attention to general health is indicated. Locally the refractive error must be corrected, and in blepharitis squamosa soothing mercurial ointments are applied at night, and alkaline lotions are used in the morning to remove the scales.

In blepharitis ulcerosa the infected lashes must be epilated, and vaccine treatment is of great service in the protracted cases. Both forms of blepharitis strongly resist treatment, which must often be continued over a period of years.

Hordeolum (Stye).—This is an inflammation of the sebaceous (or oil) gland which opens into the hair follicle of the eyelash. It is intensely painful, and it produces a localised redness and swelling at one part of the lid margin. The skin over the swelling gets redder and redder, and the swelling gradually increases. Later pus makes its appearance as a yellowish spot in the red swelling, and it generally bursts through near the border of the lids. After the escape of the pus the swelling and redness rapidly abate. Patients often have repeated attacks, as, owing to their weakened condition, they are liable to reinfect themselves.

In the acute stage the application of hot fomentations and the incising of the swelling rapidly cut short the attack. To prevent recurrence, the refractive error must be corrected, and in the most obstinate cases the patient's resistive powers must be raised by vaccine treatment.

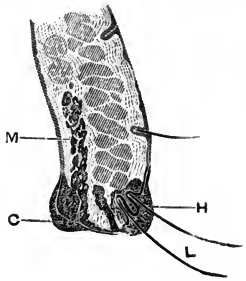


Fig. 22.
Vertical section of lid, showing the different sites occupied by hordeolum and a marginal chalazion.
H Hordeolum. *L* Eye lash. *C* Chalazion. *M* Meibomian gland.

Chalazion or Meibomian Cyst.—This is a chronic affection of the Meibomian glands. It was formerly supposed to be due to an obstruction in the duct preventing the outflow of the secretion (sebum), but more probably it is an inflammatory condition caused by microbes. It appears as

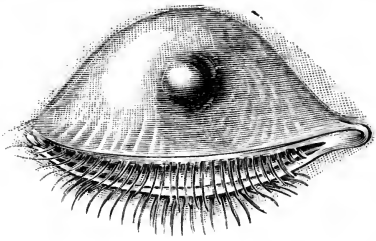


Fig. 23.
Chalazion on upper lid, the eyelids being gently closed.

a small hard swelling, generally in the upper lid, which gradually becomes larger and larger until it reaches the size of a pea or bean. The skin over the swelling is movable, and can be displaced from side to side. Later the chalazion undergoes degeneration, a viscid fluid forming in its centre, thus producing a cyst. This fluid increases, and the cyst generally ruptures on the conjunctival surface of the lid, or more rarely on the skin surface.

Occasionally the cyst becomes infected by microbes, and a small abscess then results. Chalazia affects adults more than children, and are often associated with refractive errors and conjunctival catarrh.

Prevention consists in the prescription of correct glasses and the treatment of any local catarrh. To remove the chalazion it is necessary to incise it and curette its walls.

IRREGULARITIES IN POSITION OF THE BORDERS OF THE LID.

Trichiasis.—This consists in an irregular displacement of the lashes, which, instead of looking forward, are directed more or less backward, coming in contact with the cornea. It may be partial, or may involve the whole of the cilia, but even when of slight degree the displaced lashes cause great irritation by brushing against the cornea, causing the latter to become inflamed, and not infrequently ulcerated. A constant sense of a foreign body in the eye, accompanied by photophobia and lachrymation, is always present. Later, superficial opacities are produced on the cornea, chiefly on the lower section. Not infrequently persons are tormented by recurring ulcers, until at length the physician discovers a minute lash, incurved and touching the cornea, which has been the cause of all the trouble.

For the natural growth of the lashes it is necessary that the follicles shall be healthy, and also placed in a proper position in the lid. Trachoma displaces the follicles, and is the most frequent cause of trichiasis.

Distichiasis is a congenital condition in which there are two rows of cilia, one looking forwards, and the other directed backwards.

Active treatment must be directed against any cause of the trichiasis which may be present, as blepharitis ulcerosa and trachoma.

It is not only necessary to epilate the incurved lashes, but the follicles must also be destroyed in order to prevent the lashes growing again. This is generally accomplished by electrolysis. Where many lashes are affected, epilation is not suitable, and the condition is rectified by an operation on the lid.

Entropion.—In this condition the margin of the lid is rolled inwards. The distinction between entropin and trichiasis is only one of degree. In the latter the border of the lid is properly situated, but the posterior margin of the lid is rounded off, and the cilia are turned backwards. In entropion the whole margin of the lid is turned in, and we can only see it by drawing it outwards. The evil results of entropion are the same as those of trichiasis. Two varieties of entropion are distinguished according to the causal lesion.

Entropion spasticum.—The incurved margin is caused by a more or less constant spasm of the orbicularis muscle which closes the eye, especially when the skin of the lid is redundant and flabby. The spasm of the orbiculosis, so called blepharospasm, is sometimes met with in elderly people.

Cicatricial entropion.—This is due to a conjunctival scar, resulting perhaps from trachoma, or a burn, contracting and pulling the lid in. Generally operative measures have to be resorted to as a remedy for entropion.

Ectropion consists in an outward rolling of the lid, so that its conjunctival surface looks forward, and is entirely the opposite of entropion. There are many degrees, and the lowest is where the internal margin of the lid stands off a little from the eyeball—eversion of the border of the lid. With the eversion of the lid the puncta are not in apposition with the eyeball, and so the tears cannot escape into the tear duct, and thus overflow on to the cheek (epiphora).

The epiphora tends to cause more eversion of the lid, owing to producing increased redness and thickening of the conjunctiva, and so a vicious circle is created, and natural return to the normal cannot take place. The condition gradually increases until the larger part of the conjunctival surface of the lid becomes exposed; the exposed conjunctiva then hypertrophies, and occasionally looks like proud flesh. Ectropion is most common in the lower lid, and is the result of blepharitis, trachoma, and other chronic conjunctival troubles.

Operative treatment is generally indicated, and in the early stages merely slitting up the canaliculus, in order to make an outlet for the tears, often suffices. Local treatment must be directed against the cause of this condition. The patient must be warned to wipe away his tears from below upwards, and not, as is usually done, from above downwards, as the latter procedure draws away the puncta further from the eyeball.

Lagophthalmus.—This is an incomplete closure of the palpebral fissure when the lids are closed. In the lesser degrees, squeezing the lids tightly together will effect a closure, but in sleep—when there is only a gentle closure, and the eyeballs roll upwards—the eyes will remain open, and the lower part of the cornea is exposed to the air. As the result of this the cornea becomes dry and inflamed in the exposed area, and later ulceration will take place, unless the eye is kept closed by a pad and bandage applied at night.

AFFECTIONS OF THE PALPEBRAL MUSCLES.

Spasm of the Orbicularis (Blepharospasm).—The orbicularis muscle is attached at the inner and outer canthi, and between them it spreads completely over the lids. Its function is to close the eye, and it is supplied by the facial or seventh nerve. In blepharospasm the lids are constantly screwed together, and it is either an accompanying symptom of other eye diseases, or it forms a disease by itself—essential blepharospasm or nictitation.

In the following diseases blepharospasm is a prominent symptom :—

(1) In the lodgment of foreign bodies in the eye;

(2) In corneal diseases, especially those accompanied by ulceration.

(3) In phlyctenular conjunctivitis.

(4) In increased sensitiveness of the retina, which is occasionally seen in anæmia and debility.

Essential blepharospasm is distinguished by the fact that in it the eyes themselves are found to be perfectly normal. It generally attacks young persons and the female sex, and is extremely annoying to the patient, as the constant spasm prevents them doing any continuous work.

All sources of irritation must be carefully searched for, and the refractive error corrected. In some cases relief is not obtained by these means, and tinted glasses become necessary, but are only advisable after exhaustion of all other remedial measures.

Paralysis of the Orbicularis.—This condition is only found in conjunction with paralysis of the other facial muscles. The patient cannot close his eye tightly, and the lower lid falls away slightly from the eyeball, causing eversion of the puncta and epiphora.

Ptosis (Drooping of the Upper Lid).—The upper lid is raised by the levator palpebræ superioris muscle, which is supplied by the third nerve. Muller's muscle, a small layer of unstriped muscle fibres, supplied by the sympathetic nerve, also slightly assists.

All degrees of ptosis exist, from a slightly noticeable drooping of the upper lid, to a complete prolapse of it; the lid, devoid of wrinkles, almost completely covering the eyeball.

So long as the ptosis is not so marked as to cover the pupillary area, no interference with vision results, and even where it does hang down slightly in front of the pupil, the patient, by tilting his head backwards and wrinkling his forehead, can to some extent overcome the difficulty.

Ptosis may be either acquired or congenital. The former is due to paralysis of the third nerve, and other ocular muscles will be similarly affected.

A slight drooping of the lid, together with a dilatation of the pupil, is due to interference with the sympathetic nerve, and enlarged glands in the neck are often the cause of such interference. Congenital ptosis, unlike acquired, affects both eyes.

In congenital ptosis an operation is necessary, and in the acquired form the nerve lesion must be treated.

ANATOMY OF THE CONJUNCTIVA.

The conjunctiva is a delicate membrane lining the internal surface of the lids (palpebral conjunctiva) and the anterior surface of the eyeball (ocular or bulbar conjunctiva). The palpebral conjunctiva is firmly adherent to the tarsus, and at the anterior free margins of the lids it

becomes continuous with the skin, whilst posteriorly it is reflected on to the eyeball, the line of reflection being termed the fornix. To see the lower fornix, the lower lid must be drawn down, whilst the patient looks upwards. The upper fornix is difficult to see, unless we make a double eversion of the lid. It is the loosest part of the conjunctiva, the latter being so abundant as to lie in horizontal folds, and thereby free movement of the eyeball, independently of the lid, is ensured.

The conjunctiva bulbi covers the anterior surface of the eyeball, and has no aperture corresponding to the cornea, but continues, though only as a few epithelial cells, over the latter. The bulbar conjunctiva is much paler than the palpebral, and is loosely connected with the sclerotic by a layer of areolar tissue—the conjunctival or episcleral tissue—but around the corneal margin the conjunctiva is firmly adherent to the sclera, and is here called the "limbus conjunctivæ." At the inner side of the eye (inner canthus) the reflection of the bulbar conjunctiva on to the upper and lower lids forms a vertical fold known as the plica semilunaris, which is a vestigial remnant of the third eyelids, seen in birds. This fold forms the outer boundary of a small space called the lacus lachrymalis, in which is situated a red fleshy elevation, the lachrymal caruncle, upon which a few downy hairs are often found.

The conjunctiva is not richly supplied by blood vessels, those present being twigs from the terminal branches of the ophthalmic artery. Upon the globe the vessels form a slender radiating network, gradually diminishing in size as they pass from the periphery to the cornea. This accounts for the redness, in conjunctival inflammations, being more marked at the periphery than around the cornea. The nerve-supply is from the ophthalmic division of the fifth nerve. Numerous glands, secreting mucus, which acts as a lubricant, are found in the conjunctiva.

DISEASES OF THE CONJUNCTIVA.

Conjunctivitis.—The slighter forms are called catarrhal conjunctivitis, and the severer, purulent ophthalmia or acute blennorrhœa.

Catarrhal Conjunctivitis.—The patient complains of slight itching and burning in the eyes, often accompanied by the sensation of the presence of a foreign body, due to flakes of tough mucus in the conjunctival sac. A characteristic feature of catarrh is that the symptoms are least pronounced in the morning, but gradually increase as the day passes on. The inflammation causes increased secretion, which in the slight cases is merely mucus, but in the severe types is of a purulent character (matter). The secretion dries upon the edges of the lids during sleep, and, on waking, the latter are gummed together. Photophobia (intolerance of light) is not a prominent symptom. The cornea is clear, and the pupil reacts to light.

Refractive and muscular errors are the commonest causes of those mild cases, in which there is only slight redness and secretion, but where the injection is greater, and the secretion more profuse, microbes are the exciting cause. Certain microbes produce definite clinical types of conjunctivitis.

Angular Conjunctivitis.—This is a very common type, and the redness is only, or specially, marked at the inner and outer sides of the eye. It is due to a specific organism called "diplobacillus." The correction of the refractive error never cures this condition, however mild it appears.

Pink Eye.—Another common acute catarrhal condition, popularly called "pink eye," or blight, owing to the uniform reddish appearance of the white part of the eye, is caused by another specific organism. It is very infectious, and chiefly affects children.

Conjunctivitis sometimes occurs after the action upon the eye of intense light as that reflected from snow, or direct from the electric arc. There is intense conjunctival injection, pain, photophobia and lachrymation, also slight opacities and erosions of the cornea occasionally occur. These symptoms are produced by the action of the ultra violet rays.

Diagnosis.—The gumming of the lids is the most important sign. By focal illumination mucoid secretion is seen upon the conjunctiva, and often on the edges of the lids. The redness of the eye, due to conjunctival vessels, has to be distinguished from the injection due to dilatation of the ciliary vessels caused by deeper inflammations of the eye, as in keratitis, iritis and cyclitis. The following states the differences:—

Conjunctivitis.	*Keratitis.*	*Iritis.*
Gumming of lids.	Not present.	Not present.
Not much photophobia.	Great photophobia.	Much photophobia.
Very slight pain.	Great pain.	Great pain.
Redness of eye deepest at periphery, and scarlet in color.	Deepest around cornea, and pale red in color.	Deepest around cornea, and pale red in color.
Individual vessels plainly seen, tortuous in shape, and move with the conjunctiva, as can be shown by asking patient to look up, and then moving the lower lid on the eyeball.	Vessels not distinctly seen, and do not move with conjunctiva, as they are situated beneath it.	Vessels not distinctly seen, and do not move with conjunctiva, as they are situated beneath it.
Cornea clear.	Cornea hazy.	Generally clear.
Pupil active.	Pupil contracted, but dilates regularly.	Pupil contracted, and dilates irregularly.

Acute Blennorrhœa (or acute purulent conjunctivitis).—This occurs most frequently in babies about a week old, and is generally due to the gonococcus microbe. The lids and conjunctiva become very red and swollen, and pus literally pours from between the lids in a severe case. Infection of the cornea frequently takes place, resulting sometimes in its destruction. It is one of the commonest causes of blindness.

Chronic Catarrhal Conjunctivitis is rarely the sequel of an acute attack, but generally occurs in patients who are below the usual standard of health, and in those whose livelihood entails long-continued use of their eyes for fine work, especially if any refractive or muscular error be present. The eye is red and irritable, and often a sense of discomfort, and some watering (lachrymation), on exposure to light are complained of. Reading tires the eye, and causes it to become more reddened. In old people the frequent dragging upon the lower lid in the act of wiping the eye, on account of the slackness of the tissues, causes the punctum to be slightly drawn away from the eyeball, and the tears overflow on to the cheeks. This excoriates the lids and aggravates the symptoms, forming a vicious circle, and preventing a natural cure from ever taking place.

Correction of refractive and muscular errors is most important. Local applications, as boric acid, zinc sulphate, etc., hasten the patient's progress. Where the punctum is everted, surgical measures are generally indicated, such as slitting up the canaliculus.

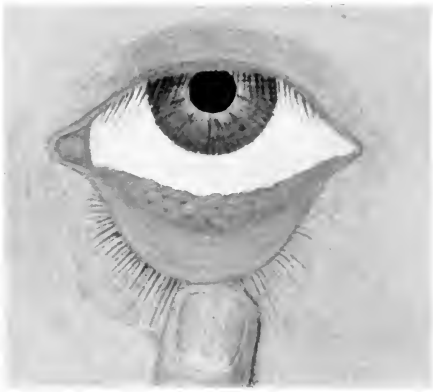
Follicular Conjunctivitis is characterised by the presence of follicles, situated chiefly in the lower fornix, which is seen on everting the lower lid. They are small round granules, slightly smaller than the head of a pin, and of a pale and translucent aspect, puffing up the conjunctiva in the form of small eminences. A few or many may be present, and in the latter case they are arranged in rows. The symptoms are those of conjunctival irritation. The follicles are met with in young boys, especially those with refractive errors, and it is very important to distinguish this affection from trachoma, which is an infectious and very serious disease, owing to the tenacity with which it resists treatment. The differences are shown herewith

Follicular Conjunctivitis.	*Trachoma.*
Slight redness and irritation of eyes.	Slight redness and irritation of eyes.
Follicles generally in lower fornix, but *never* on palpebral conjunctiva.	Follicles commonly in upper as well as lower fornix, and always on palpebral conjunctiva.
Arranged in rows.	Scattered irregularly.
Does not cause subsequent scarring of conjunctiva.	Always followed by scarring.
Never infects cornea.	Commonly causes a gelatinous infiltration of upper part of cornea, so called "pannus."
Occurs in boyhood, especially in hypermetropes, and treatment consists in correction of refractive error.	Generally in adolescence and in aliens, especially Jews.

Trachoma may cause great diminution in vision, when pannus is present, and the subsequent cicatrisation in the conjunctiva predisposes to entropion and ectropion of the lids, and various other sequelæ of a permanent character.

The great distinction between follicular conjunctivitis and trachoma is that the latter always affects the palpebral conjunctiva of upper lid, and the former never. In doubtful cases the upper lid should be everted and follicles looked for.

A



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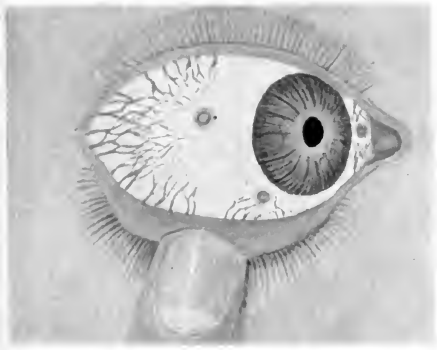

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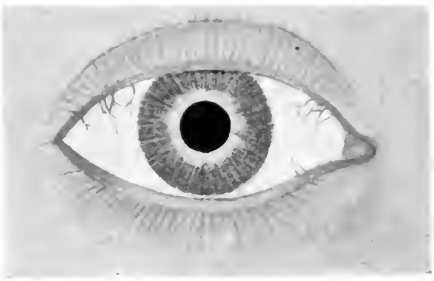

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PLATE I.

A.—TRACHOMA AND PANNUS.

Note.—Irregularly placed follicles on fornix and palpebral conjunctiva. Gelatinous infiltration of upper part of cornea (pannus).

B.—FOLLICULAR CONJUNCTIVITIS.

Note.—Follicles in rows on fornix, the palpebral conjunctiva being free. Cornea clear.

C.—PHLYCTENULAR CONJUNCTIVITIS.

Note.—Three phlyctenes are shown, the redness being chiefly around them, other parts of the conjunctiva being free from injection.

D.—ANGULAR CONJUNCTIVITIS.

Note.—The redness is confined to the inner and outer angles of the eye.

Conjunctivitis Eczematosa or Phlyctenular Conjunctivitis occurs in childhood, and photophobia (intolerance to light) is one of the characteristics of this disease. So intense is it that occasionally the child creeps into a dark corner of the room, and strenuously resists any attempt made to open its eyes. The intensity of the symptoms bears an inverse ratio to the severity of the disease, the slighter the case the severer the symptoms. In its simplest form it presents the following picture: A little red swelling, about the size of a millet seed, develops generally at the corneal margin (limbus conjunctivæ). At first it is conical, and epithelium covers its apex, but later this breaks down, and a small ulcer is formed. The reddened portion of the conjunctiva is in the shape of a triangular sector, with its apex at the nodule. The remainder of the conjunctiva is normal. Frequently there are several nodules appearing at the same time, and often they form on the cornea. Acne of the conjunctiva and episcleritis are the only conditions likely to be confused with this disease.

Pinguecula.—The atmospheric influences (wind, dust, etc.) produce changes in that portion of the conjunctiva exposed to them. This area is called the inter-palpebral part, and in elderly people a thickening of the conjunctival tissue is sometimes noted here. This thickening often assumes a yellowish colour, largely due to the formation of numerous concretions of a yellowish hyaline substance, and is called a pinguecula. As a result of these changes, the pinguecula does not allow the red colour of the blood to shine through as plainly as the non-thickened adjacent conjunctiva, and it might be confounded with a small pustule by a beginner. No symptoms are caused, and treatment is rarely indicated.

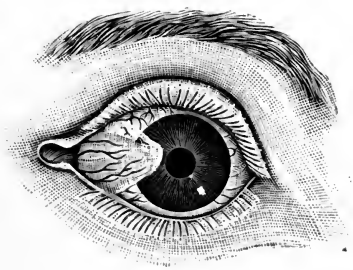


Fig. 24.
Pterygium.

Pterygium.—This is a peculiar growth of the conjunctiva and subconjunctival tissue. Triangular in shape, with its base (so-called body) at the semilunar fold, close to the inner canthus, it extends outwards, tapering to a rounded end (called the head), which gradually spreads on to the cornea, and becomes solidly and immovably united to it. In recent and progressive

cases the pterygium is red, fleshy and prominent; but in regressive ones it is pale, membraneous and almost translucent. It rarely spreads beyond the centre of the cornea. Generally it affects patients about middle age. A pterygium probably originates from a pinguecula, the degenerative process which exists there making its way into the limbus, and then gradually upon the cornea itself. The treatment is surgical, and consists in thorough removal.

Lipoma (fatty tumour of eye).—This occurs at the outer part of the eye, and is congenital in origin. It appears as a solid, fatty-looking and ill-defined growth, and when large surgical treatment should be resorted to.

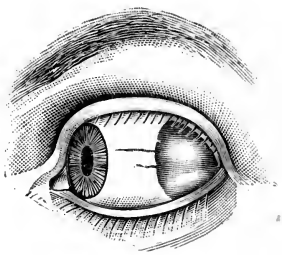


Fig. 25.

Subconjunctival Lipoma.
The eye is strongly adducted, to bring the tumour into prominence.

INJURIES OF CONJUNCTIVA.

Sub-conjunctival hæmorrhage may arise from a blow on the eye, an attack of coughing, or over-exertion. The blood appears as a bright red mark strictly limited to a portion of the conjunctiva. It is of only slight significance, and causes no symptoms, but the vivid redness may unnecessarily alarm the patient. Its dispersion is aided by hot fomentations, and generally takes two or three weeks.

In fractures of the skull, involving the orbital plate, a large subconjunctival hæmorrhage appears, but its upper margin cannot be defined. Such cases should always be at once referred to a medical man.

Foreign Bodies on the Cornea, or on the Conjunctiva lining the Lids.—Small-sized foreign bodies, as grains of dust, particles of coal or ashes, first fall upon the surface of the eyeball, and are brushed away by movements of the upper lid, generally sticking to its inner surface near the lid border, where there is a small furrow—the sulcus subtarsalis—in which the foreign body lodges.

There is great irritability of the eye, accompanied by a copious flow of tears, an inability to raise the upper eyelid and face the light, and a distinct feeling of grittiness, as if something were in the eye. The suddenness of the attack, and the exposure to which the eye has been subjected are points to be noted, but confirmation can be sought only in the detection of the foreign body, as many acute inflammatory conditions commence in a similar manner.

The cornea should be carefully examined by focal illumination, and if the foreign body is detected there, an attempt should be made to remove it, using the hem of a handkerchief or a blunt-pointed instrument. If unable to displace the body, it is wiser to refer the case to an oculist, as, being imbedded in the cornea, it necessitates the instillation of cocaine and the use of a sharp-pointed instrument ere it is dislodged. The chief danger in using the latter is not that of entering the anterior chamber, but of introducing sepsis, and causing a septic ulcer.

If a foreign body is not detected, then the lower lid should be everted by placing the tip of the thumb or finger on the lower margin of the lid and drawing it well downward. This allows observation of the lower fornix. The patient is now asked to look up, and at the same time the thumb is pushed backwards over the rim of the bony socket, so everting the lid and bringing the palpebral conjunctiva well into view.

If a foreign body is not present, then the upper lid should be everted. This is more difficult than eversion of the lower one, especially in small eyes and where there are projecting brows. It is essential for its success that the patient not only looks down, but continues looking down until the lid is everted; and in his instinctive tendency to look up, when any traction is made on the lid, lies the main reason of failure.

In examining an eye in which a foreign body is suspected to be lodged, place the patient in a good light. First examine carefully the cornea, then the lower lid and fornix, and lastly the upper lid and fornix. The symptoms are immediately relieved on removal of the foreign body, except in those cases in which it is imbedded in the cornea.

Methods of Everting the Eyelids.

The following is a detailed description of methods of inversion:—

You may stand either behind or in front of your patient. Direct him to look down, and seize, between the forefinger and thumb (using right to right eye, and left to left eye), the upper lashes, at their attachment to the lid, drawing them gently away from the eyeball (Fig. 26). At the same time, with the other hand, place some blunt instrument (match, end of pen.

or tip of finger) *above* the upper edge of the tarsal cartilage, and whilst exerting pressure downwards with this, pull upwards on the lashes, thus everting the lid over the match, using the latter as the fulcrum. The finger then, by gentle pressure on the everted lid, maintains it in position until the foreign body is removed.

Occasionally the foreign body is situated in the upper fornix, and to expose that it is first necessary to evert the upper lid, and then push up the lower lid under the lower edge of the upper inverted lid, so further inverting it. The patient must be looking downwards as far as possible to render this manœuvre successful.

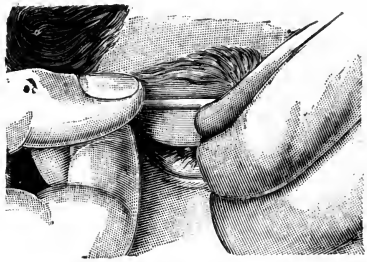


Fig. 26

Showing method of everting the upper lid with a match.

The best method of everting a lid is performed solely by the fingers (using right hand to left eye, and left to right eye), as not only can both lids be everted simultaneously, but the tendency of a patient to look up—so fatal to a successful eversion—is greatly minimised. To do this, stand before patient; place tip of thumb on the centre of lower lid, and push the latter slightly up, whilst asking the patient to look up. Now tell patient to look down, and at the same time raise the upper lid slightly from the eyeball by tip of finger placed *above* upper edge of tarsal cartilage, and you will notice that the upper lid falls gently over the lower. Whilst pressing slightly downwards and backwards with the forefinger on the upper lid, you evert it by pressing the lower lid upwards against the inner and marginal surface of the upper, using the lower as the fulcrum. Very little practice is necessary to become accomplished in everting the lid in this manner, and when such has been gained, the method offers the easiest, and to the patient the least disagreeable, procedure.

EVERSION OF LIDS BY FINGERS ALONE.—

Fig. 27

The lower lid is pushed up by thumb, whilst patient is looking upwards.

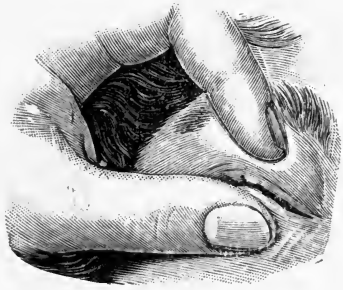


Fig. 28

Shows upper lid lying over marginal part of lower.

Fig. 29

Everted upper and lower lids.

THE LACHRYMAL APPARATUS.

Chapter IV.

ANATOMY.

The lachrymal organs consist of the lachrymal glands and the lachrymal passages. The principal lachrymal gland lies in a depression situated at the outer angle of the orbit, upon the under surface of the upper bony orbital wall, but there are smaller ones beneath the conjunctiva of the fornix, situated towards the inner angle. The lachrymal passages are conveniently divided into three parts—(*a*) the canaliculi, (*b*) the lachrymal sac, (*c*) the nasal duct.

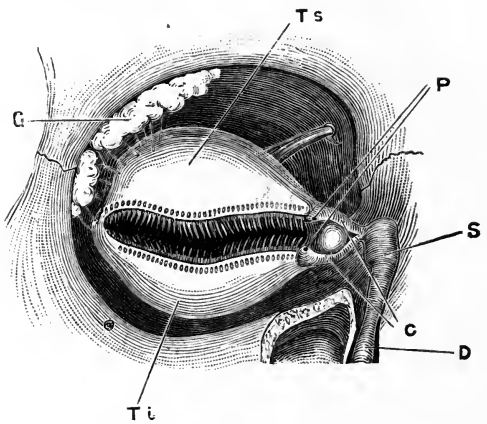


Fig. 30.

Dissection of the Lachrymal Apparatus.

C Canaliculi. *D* Duct. *G* Glands. *S* Lachrymal sac. *P* Puncta. *Ts* & *Ti* Superior and inferior tarsi.

The gland secretion empties itself into the outer half of the upper conjunctival fornix, and the tears flow across the eyeball, and escape into the lachrymal passages through two minute openings—one in either lid—stationed on their margins near the canthus, and termed the puncta lachrymalia. Each punctum is in apposition with the eyeball, and can only be seen on slightly everting the lid margin. The puncta are situated upon small elevations, and they open into the lachrymal canals or canaliculi. The upper canaliculus runs upwards, and the lower downwards for a short distance, and then they bend at right angles and become directed towards the lachrymal sac, converging more and more as they approach the sac, and opening into the latter either separately, or after having united to form a short common canal.

The lachrymal sac lies in the inner angle of the eye, beneath the internal tarsal ligament. The latter can be distinctly felt, when the eye is turned outwards, as a tense band beneath the skin, and it forms a most important guide to the sac. The sac is a membranous bag measuring about $\frac{3}{8}$ in. in length, and is capable of great distension. Its summit is blind, and reaches a little above the level of the tarsal ligament, whilst inferiorly it opens by a somewhat constricted orifice into the nasal duct. The nasal duct is about $\frac{3}{4}$ in. long, and opens into the lower part of the nose, called the inferior meatus.

The mucous membrane of the lachrymal sac and that of the duct form one continuous whole, there being no sharp dividing line between them, but the duct lies in an osseous channel—being completely surrounded by bone—and so cannot become distended, whilst the sac has no bony surroundings in front, and distension readily takes place when the duct is obstructed. The tears consist of water, with a slight admixture of sodium chloride (common salt). Normally, except under the influence of emotion, the secretion is only just sufficient for lubricating purposes, and so tears are not constantly dripping into the nose. Some uncertainty prevails as to the factors most important in the excretion of tears, but the act of winking, together with the movements of the eyeball, serve to carry them across to the inner side, whence, for their removal into the canaliculus, correct adaptation of the puncta to the globe is indispensable. The lachrymal sac has in front of it the internal tarsal ligament, and behind it a small muscular layer derived from the orbicularis muscle, called Horner's muscle, and it is generally thought that the entry of tears into the canaliculi is facilitated by compression of the sac between the ligament and the muscle, thus producing suction, but in any case the rate of outflow is only slight, and if tears be secreted in any quantity they overflow on to the cheek.

AFFECTIONS OF THE LACHRYMAL APPARATUS.

These are manifested by an overflow of tears, which, when caused by over-production, is called lachrymation, and when due to interference with the outflow of tears is named epiphora.

Lachrymation is an actual hypersection of tears, which escape on to the cheek owing to the rapidity with which they are secreted, and occurs in many eye conditions, especially affections of the cornea, and to a less extent those of the conjunctiva, iris, ciliary body and retina. Lachrymation is also a prominent symptom in some nasal affections.

Epiphora expresses an overflow of tears caused by some imperfection in the excretory part of the lachrymal apparatus, and this in turn causes the escape of tears to be interfered with. They then accumulate at the inner angle of the eye, and from time to time escape on to the cheek. The epiphora is aggravated by exposure of the eye to cold or wind, which cause an increased production of tears.

Epiphora may arise from:—

(1) *A displacement of the punctum*, without any mechanical obstruction in the canaliculus, lachrymal sac or nasal duct. In old people the lower lid frequently falls slightly away from the eyeball, owing to a diminished tone of the orbicularis muscle, and then the punctum does not lie in apposition to the globe. In ectropion a further displacement of the punctum is present, whilst in entropion an inversion of the punctum prevents the tears from escaping into the canaliculus. In these cases the cause of the epiphora is at once evident, and treatment consists in placing the punctum in proper position against the eyeball.

(2) *Obstruction of the canaliculus.*—It may then be due to a foreign body, as a chalky concretion from the tears, or to closure of the lumen (or open passage) as the result of inflammation. In these cases it will be noted that the punctum is in place, and, further, that on pressure being applied over the lachrymal sac no return of the tears into the eye *via* the canaliculi is obtained, which would be the case if the canaliculi were patent, and there was an obstruction in the sac or below it.

(3) *Obstruction in the lachrymal sac or nasal duct.*—In the early stages no dilatation of the sac is noticeable, but on pressure over the sac (the patient turns the eye out, and pressure is applied firmly over the internal tarsal ligament) the lachrymal fluid is forced back into the eye, as the obstruction in the duct prevents its escape into the nose.

In the later stages the lachrymal sac becomes distended, owing to the continual accumulation of tears, and the distension appears externally as an elongated oval swelling, situated between the inner angle of the eye and the nose, chiefly below the level of the tarsal ligament. This condition is called a mucocele, and on pressure over it, the contents, consisting chiefly of muco-pus, are squeezed back into the eye. The muco-purulent character of the fluid is owing to the tears, when stagnated in the sac, being a good medium for the growth of microbes.

Treatment in the early stages consists in syringing and probing the sac and duct, but later, when a mucocele has developed, only excision of the sac provides permanent relief.

A not uncommon cause of epiphora is an improperly fitting pince-nez, the plaquets, by undue pressure on the skin, occasioning a slight separation of the lower punctum from the globe.

THE CORNEA.

Chapter V.

ANATOMY.

The cornea, together with the sclera, represents the outer fibrous envelope of the eyeball, the cornea constituting the transparent portion. It has the form of a horizontal ellipse, the horizontal diameter averaging twelve millimetres and the vertical eleven millimetres. It is thickest at the periphery (about 1 mm.), and thinnest in the centre, and is inserted into the sclera like a watch glass, its posterior layers extending further into the sclera than the anterior ones. The cornea is non-vascular, but permeated by lymph channels, and the nutriment enters it from the network of vessels around the margin, and probably also from the anterior chamber.

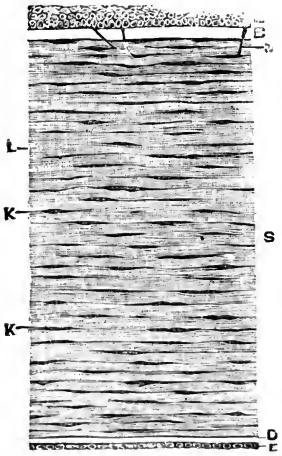


Fig. 31.

Cross-section through cornea, magnified 70 diameters.

E Anterior epithelium. *B* Bowman's membrane. *S* Stroma, composed of lamellae (L) and corpuscles (K). *D* Descemet's membrane. E Posterior epithelium. N Nerves extending through Bowman's membrane and epithelium.

The cornea is richly supplied with nerves from the ciliary and conjunctival plexuses, which ramify very extensively in the superficial layers, and also penetrate the epithelium, so accounting for its extreme sensibility and the severe pain accompanying superficial corneal abrasions.

The cornea consists of the following layers from before backwards:—

(1) *Several layers of transitional epithelium*, the most superficial being more flattened than the others.

(2) *Bowman's membrane*, a delicate homogeneous substance, which is really only the upper part of the next (or third) layer.

(3) *Substantia propria*, or corneal substance proper, consisting of bundles of fine connective tissue arranged in well-defined lamellæ, and united by cross fibres. Between the bundles are the above-mentioned lymph channels, in which lie large flat branching cells—the corneal corpuscles.

(4) *Descemet's membrane*, a homogeneous elastic membrane, the product of the endothelial cells covering its posterior surface. It is very tough, and offers great resistance in cases of destructive ulceration of the cornea.

(5) *A layer of flattened cells* continuous with the epithelium covering the iris.

The cornea is transparent in health, and all pathological changes cause a diminution of this transparency. In old age it becomes duller, its refractive index is increased, and often a narrow, greyish line, called the arcus senilis, appears near to and concentric with the margin. This generally begins at the upper and lower margins, and gradually grows round it, the outer edge being clearly cut and separated from the conjunctiva by a slight portion of clear cornea, but the inner edge shelves gradually into the clear cornea. The arcus senilis is formed by the deposition of hyaline masses and minute particles of lime in the superficial layers of the cornea.

Clinical Examination of the Cornea.—A good light and focal illumination must be used, and a powerful pocket lens is essential, in order to detect finer changes. The following points should be noted:—

(1) *The size and form of the cornea.* Both may be altered congenitally or by pathological changes.

(2) *The surface of the cornea* should be noted with regard to its curvature, smoothness and polish. If the patient's eye is directed so that the reflection of a window placed opposite is visible on the cornea, then movement of the eye will cause the reflection to fall upon different portions, and we see the reflex image becoming larger or smaller, according to the varying curvature. When the polish of the surface is lost, it appears dull, like glass which has been breathed upon. This condition is noted in acute attacks of glaucoma.

(3) *The transparency of the cornea.* Dense opacities are noticeable from a distance, but to detect the slighter ones focal illumination, and sometimes even a magnifying glass, are necessary. A slight opacity of the cornea is one of the most commonly overlooked pathological changes, and it should always be excluded in cases of diminished visual acuity.

Fig. 32.

Keratitis punctata. In A the deposits are arranged in the form of a triangle, the larger ones being below. *B* Represents the "mutton fat" form.

In inflammation of the ciliary body (cyclitis) there is a deposit upon the back of the cornea of spots of pigment, circular in shape, and often arranged in a pyramidal manner, with the apex about the centre of the cornea, but sometimes the arrangement is irregular. The name "keratitis punctata" (K.P.) is given to this condition. The spots are migratory pigment cells from an inflamed ciliary body, and they can only be seen with a corneal lens and focal illumination.

The details of a corneal condition can be well seen by examining it with the small ophthalmoscopic mirror with a + 30 D behind. First we fix the surface of the cornea, rendered evident by the slight particles of dust floating on it, and then gradually approach nearer the eye until the details of the iris are clearly seen. In this manner the various parts of the cornea are successively examined.

AFFECTIONS OF THE CORNEA.

Keratitis is an inflammatory condition of the cornea, and an important distinction is made between superficial and deep keratitis, using the terms not in relationship to the depth they may extend into the cornea, but only in relationship to their arterial supply; for instance, the blood vessels in superficial keratitis are derived from the conjunctival vessels around the margin of the cornea, the normal cornea being avascular, whilst in deep keratitis they are derived from the ciliary vessels around the limbus.

Every keratitis is manifested by a loss of lustre and transparency in that portion of the cornea affected, and is accompanied by inflammatory signs in adjacent tissues.

(1) Increased redness of the eyeball, which is most marked around the corneal margin, as it is a ciliary injection (see conjunctivitis for the difference between ciliary and conjunctival injection). The degree of injection bears a direct ratio to the severity of the inflammation. In slight cases it is difficult of detection, whilst in severe ones the injection is not only ciliary, but conjunctival as well, and the globe appears a vivid red.

(2) In the slight cases we get a hyperæmia of the iris, and a contraction of the pupil; but in deep keratitis, iritis and iridocyclitis often supervene.

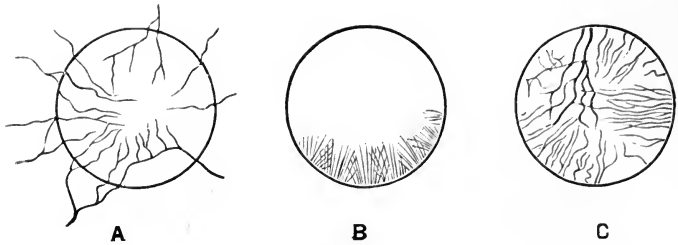


Fig. 33.

Diagrammatic section of the cornea showing new vessels.
A Superficial corneal vessels. These are sinuous, and continue unbroken on to the conjunctiva. They branch and anastomose with one another. *B* & *C* Deep corneal vessels. These disappear at the corneal margin, do not branch, and pursue a fairly straight course.

The signs which enable us to distinguish the two kinds of blood vessels are as follows :—

Superficial vessels.	*Deep vessels.*
These spring from the network of conjunctival vessels near the limbus, and can be traced directly into the conjunctival vessels.	These spring from the ciliary vessels in the sclera, close to the corneal margin, and so appear to suddenly end at the limbus, disappearing behind it to enter the sclera.
Owing to their superficial position they are clearly visible, well defined, and of a vivid red color.	They are not distinct, owing to cloudy layers of cornea lying in front of them, and are of a dirty red hue.
The vessels branch in an arborescent manner.	The vessels form fine straight twigs.
The above is seen in pannus.	The above is seen in interstitial keratitis.

(3) A white exudate appears in the anterior chamber, and is called a hypopyon, but it is only evident in severe cases. This exudate, appearing like pus, lies at the bottom of the anterior chamber, and consists of leucocytes (white blood cells, or scavengers), which have escaped from the blood vessels of the iris and ciliary body.

There are two important sub-divisions of keratitis :—

(1) *Non-ulcerative or non-suppurative*, in which the corneal epithelium remains intact, and where the inflammation does not result in the formation of pus In these conditions a complete restoration of the transparency of the cornea may take place, and normal vision be regained.

(2) *Ulcerative or suppurative keratitis.*—The corneal layers and epithelium are destroyed over the portion of the cornea infected, and an ulcer is formed. All ulcerative conditions, wherever in the body situated, heal by the formation of fibrous tissue. This is opaque, and so a return to the natural transparency of the cornea is impossible. The degree of opacity ultimately remaining depends largely on the depth of the ulcer and the age of the patient—the deeper the ulcer the greater the opacity, and the younger the patient the more it tends to clear up. Both ulcerative and non-ulcerative keratitis may be situated superficially or deeply.

(*a*) *Superficial forms of non-ulcerative keratitis.*

Pannus.—This is the most common form of superficial keratitis, and is really an affection of the conjunctival layer of the cornea (the corneal

epithelium). It may be caused by trachoma, in which case the disease affects the upper part of the cornea, or by phlyctenular conjunctivitis, when any part of the cornea may be attacked.

Trachomatous pannus (Plate I.) begins at the upper part of the cornea, and consists in the deposition, beneath the corneal epithelium, of a newly-formed, brownish, vascular tissue, which pushes its way from the edge to the centre of the cornea. It appears as a grey, translucent, gelatinous, and superficially-situated, cloudy mass, traversed by numerous blood vessels. These are derived from the conjunctival vessels, and have the distinctive features as previously described. The pannus rarely spreads below the centre of the cornea. In very severe cases it may develop at other portions of the corneal margins, and so completely envelop the cornea.

Though in slight cases the condition may clear up, leaving the cornea transparent, yet the newly-formed tissue is frequently partly transformed into fibrous tissue, which appears as a dirty greyish opacity, limited to the upper part of the cornea, with conjunctival vessels ramifying in it.

Pannus eczematosus.—This is due to phlyctenular conjunctivitis, and is differentiated from trachomatous pannus by its being situated in any portion of the cornea. Also an examination of the lids reveals the absence of trachoma.

Keratitis vesiculosa.—The formation of small clear vesicles on the surface of the cornea is distinctive of this affection, and it is often associated with neuralgia of the supra-orbital nerve. The vesicles themselves are rarely seen, as their walls consist only of the corneal epithelial layer, and pressure of the lids quickly ruptures them, only a tag of corneal epithelium being noticed. A tendency to frequent recurrences is characteristic of this affection.

(*b*) *Deep Keratitis.* In these conditions the infiltrate develops in the middle and deep layers of the cornea, and they are often accompanied by inflammation of the uveal tract (the ciliary body and iris). The only common variety of deep keratitis is

Interstitial or parenchymatous keratitis.—It is a disease of youth, generally appearing between the sixth and twenty-first year, and is nearly always caused by congenital syphilis. Tubercular tendencies are also suggested as a causal factor. In congenital syphilis the teeth are abnormally shaped. They are peg-shaped, and the upper incisor teeth show a deep semi-lunar indentation, and are called "Hutchinson's teeth." These changes exist only in those of the second dentition.

Fig. 34.
Teeth in congenital syphilis.
(Hutchinson's Teeth.)

There may be slight pain in the eye, but photophobia and lachrymation are often the only symptoms. Sometimes the disease begins in the centre of the cornea, and at other times at the periphery, but it invariably affects both eyes, first one and then the other. It commences as a diffuse haziness, either centrally or peripherally, accompanied by ciliary injection. The lustre of the cornea is lost over the area attacked. Deep blood vessels (Fig. 33) grow in from the margin, and the haziness gradually spreads, until sometimes the whole of the cornea becomes opaque. Great variations exist with regard to the density and extent of the infiltration, and generally the worst cases are those which commence in the centre of the cornea. Variations also exist with regard to the number of blood vessels present; in many cases they are so abundant that the cornea presents an appearance like red cloth, whilst in others they are so scarce that the condition appears like white ground glass.

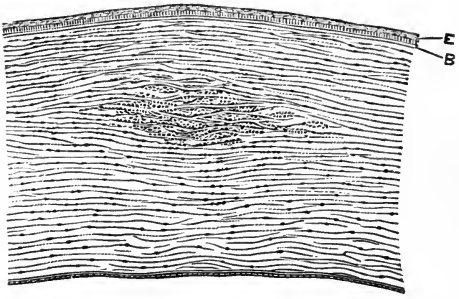


Fig. 35.

Infiltrate in the cornea.

The Epithelium (*E*) and Bowman's membrane (*B*) over the infiltrate, are preserved.

The great variations in the clinical picture of parenchymatous keratitis offer difficulties to the beginner, but one must bear in mind that it never forms an ulcer—the corneal epithelium always being intact—and that the blood vessels are derived from the ciliary vessels. In this condition, especially in the more severe types, we get an accompanying inflammation of the iris, ciliary body and choroid. The outlook in this disease is unfavourable in the severe cases, as marked diminution of visual acuity generally persists, but in the milder forms vision is only slightly reduced, the cornea becoming more or less transparent again. It is always chronic in its course, averaging about nine months.

Other uncommon forms of deep keratitis are sclerosing keratitis and keratitis profunda.

Ulcerative keratitis.—In these cases there is an infiltrate, situated superficially in the cornea, which rapidly spreads and forms pus. It breaks through the corneal epithelium, and in this way a superficial loss of substance is produced, resulting in the formation of an ulcer, recognisable as a depression on the corneal surface. An ulcer is stated to exist when there is a discontinuity of the corneal epithelium.

The symptoms are, great pain, especially on movement of the lids (the patient often assuming that it is only a foreign body in the eye), lachrymation and photophobia. The severity of the symptoms bears a direct ratio to the severity of the disease.

The eyeball appears reddened owing to conjunctival and ciliary injection, and, in the severe cases, the bulbar conjunctiva becomes swollen. This condition is called chemosis of the conjunctiva. Over the superficially disposed infiltrate in the cornea, the surface is dull and the cornea cloudy. Then the epithelium over this breaks down, thus creating an ulcer. This is surrounded by infiltrated portions of the cornea (recognised by the grayness of the base and walls of the ulcer), which in severe cases continues to spread both deeply and peripherally, at the same time breaking down, and so making the ulcer both larger and deeper. In some cases this extends as far as Descemet's membrane, which, owing to its great resistive powers, is protruded by the intra-ocular pressure, appearing as a transparent vesicle at the base of the ulcer. This is called a keratocele. Later the vesicle may rupture, and then a perforation of the cornea occurs, resulting in the escape of the aqueous tumor through the perforation. The anterior chamber being obliterated, the iris and lens, in the region of the pupil, are applied to the posterior layer of the cornea.

When an ulcer is extending, we speak of it as in the progressive stage. This is recognised clinically by a gradually increased extension of the infiltrated area, and by greater ciliary and conjunctival injection, and, moreover, inflammation of the iris may later make its appearance, as evidenced by turbidity of the aqueous, hypopyon (white exudate lying at the bottom of the anterior chamber), contracted pupil, posterior synechiæ, and discolouration of the iris. When the infiltration ceases to spread, the ulcer entering upon its regressive stage, cleanses itself, and the surrounding infiltration disappears, leaving a glistening base and clear sides, the symptoms gradually disappearing. After the ulcer has become entirely clean, cicatrisation commences. Blood vessels grow in from the nearest portion of the limbus (corneal margin), carrying pabulum and new cells, and the base of the ulcer again becomes clouded, but at the same time shallower, until finally it reaches the level of the adjacent normal cornea. Sometimes it does not quite reach that level, being discernible as a facet, or, owing to the diminished resistance of the cicatrix, the latter may be bulged forwards, so called ectatic cicatrix

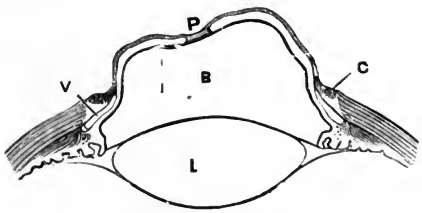


Fig. 36.

Staphyloma of cornea.

The whole cornea has been destroyed, and *I* represents the cicatrised iris. *P* The pupil, now filled in with cicatricial tissue. *B* The posterior chamber. *L* The lens. *C* Remains of cornea.

Where, in perforating ulcers, the larger portion of the cornea is destroyed, the iris becomes applied to the narrow remaining corneal rim, and the pupil and iris become covered by exudate, which later is transformed into fibrous tissue. So the anterior portion of the eye in these cases is formed by the cicatrised iris, no anterior chamber, of course, being present, but behind the iris lies the posterior chamber and lens. In these cases the scar generally bulges forwards, owing to its resistive power being less than that of the normal cornea, and this condition is called "staphyloma corneæ."

Corneal ulcers are due to infection of the cornea by microbes, and the greater their toxicity, the severer the ulceration. As only a few microbes, viz., gonococcus, diphtheria bacillus, etc., can attack an uninjured cornea, the majority of ulcerations follow abrasions of the cornea, which allow of entrance of the microbes. The prognosis, or outlook, depends upon the density of the scar and its relationship to the pupil. The younger the patient, the greater the absorption of the cicatrix.

Treatment.—In the progressive stages, hot antiseptic fomentations and the instillation of atropine are necessary. A pad and bandage is worn to prevent the friction of the lids. To reduce the density of the cicatrix, irritating ointments and lotions are introduced into the eye.

Fig. 37.

Dendritic ulcer, characterized by its arborescent shape.

Varieties of Ulcer.

Dendritis ulcers, so called from their shape—like the branches of a tree, often with nodular swellings at the extremities of the branches—are only superficial, but give rise to intense pain, and are of frequent recurrence.

Rodent ulcer.—A superficial ulcer, gradually spreading, with intervening remissions of apparent recovery, over the whole of the cornea. The spreading margin is undermined, and, if destroyed by the cautery, a cure is attained.

Ulcus serpens.—A severe ulceration, commencing in the centre of the cornea. It is discoid in shape, the opacity being more marked at the periphery than at the edge. It causes hypopyon and iritis, and often results in perforation of the cornea. It is caused by the pneumococcus organism, and is often associated with the presence of dacrocystitis. The prognosis is bad, perforation of the cornea being a frequent sequel, and even when the eye is saved, the central dense opacity greatly reduces vision.

INJURIES OF THE CORNEA.

(1) *Foreign Bodies.*—It is not uncommon for blacksmiths and iron-founders to have particles of hot iron or steel flying into the eye, and travellers—by rail or road—may have a piece of grit blown upon the surface of the cornea. A sudden onset of acute pain, greatly increased upon movement of the lids, photophobia and lachrymation are the chief symptoms, but they are not characteristic of a foreign body, as many corneal affections exhibit the same indications and rapidity of attack. On inspection of the eye, ciliary and conjunctival redness will be noted, but confirmation of the diagnosis lies only in the detection of the foreign body on the cornea. So minute are many of these extraneous particles that they may only be discovered after careful search with the aid of a corneal loupe and focal illumination. The foreign body may be imbedded—and this is usual with hot iron particles—or it may lie on the surface of the cornea. In the latter case its removal is easy of accomplishment by the aid of a blunt instrument, as a spud, or the hem of a handkerchief. If imbedded in the cornea, the case should be referred to a surgeon, as the instillation of cocaine and the use of a sharp-pointed instrument are necessary ere the body is dislodged.

(2) *Abrasions of the Cornea*—caused by scratching the eye with finger-nail (commonly found in mothers, due to baby poking its fingers in her eyes), or a stiff leaf or twig. It is followed by well-marked symptoms of irritation and violent pain on movement of lids. The slight loss of epithelium can be detected by observing the corneal reflex or by instilling into the eye fluorescin, which stains the abraded area a greenish hue. Treatment consists in the application of a pad and bandage, using sufficient pressure to prevent movement of the eyeball. Deeper wounds of the cornea may be straight or lacerated, and may extend through part or the whole of the cornea.

Burns by Caustics.—Hot water, steam, molten lead and lime are the most common agents. They cause inflammation and ulceration of the cornea. In burns by lime, the eye should be washed out with a simple oil, and then concentrated solution of sugar applied, this forming an insoluble compound of lime. Prior to the application of the oil, any solid particles of lime that may be visible should be removed, and the eye douched out with warm water. The insoluble compound of lime has no deleterious effect.

Corneal Opacities.—Opacities are generally the result of previous corneal inflammation, with or without ulceration. Different nomenclature is applied to the slight forms from those of more severity. The former are classed as maculæ or nebulæ, and the latter as leucoma.

(1) *Nebulæ or Maculæ.*—These are slight opacities, discernible only with focal illumination, but cause much diminution of visual acuity when diffuse in character and centrally situated. They appear punctate in shape, and are bluish-white transparent spots, when viewed through a corneal loupe.

(2) *Leucoma.*—This is a dense white opacity, and cannot be overlooked. It may be raised above the level of the cornea, noticeably so in a recent scar, and in the latter blood vessels will be detected, arising from the limbus and permeating the leucoma. The character of the vessels will determine whether the previous inflammation was superficial or deep. Occasionally

the leucoma may be below the level of the cornea, causing the latter to be flattened, and this condition is called "applantio corneæ." The involvement of the iris in the scar points to a previous perforation of the cornea, and may be caused by an ulcer or the surgeon's knife; in the latter case the scar will be linear in shape.

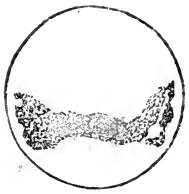


Fig. 38.
Zonular opacity of the cornea.

The disturbance of vision caused by opacities depends upon their position and density. The denser the scar, the fewer the rays transmitted through, and the more numerous are the reflected ones, but in the fainter opacities the disturbance in vision is not caused so much by the diminished transmission of the rays as by their irregular refraction, and, owing to this, a slight opacity covering the whole causes more disturbance of vision than a dense opacity, occupying only a portion of the pupillary area.

Where an irregular surface of the cornea has resulted from the cicitrisation, irregular astigmatism is present, and great interference with vision results. The disturbance of vision produced by an opacity compels the patient to bring minute objects close to his eye in order to obtain as large a retinal image as possible, and so compensate him in a slight degree for their indistinctness, and this habit increases the patient's liability to strabismus, nystagmus and myopia.

In recent cases, irritating ointments and lotions introduced into the eye increase the rate of absorption of the tissue, and the more vascular the scar the better the results. In old avascular scars no benefit is derived from such treatment, and attempts have been made, after excision of the nebula by a trephine, to transplant either a portion of the cornea of the rabbit or that of a recently extirpated human eye. This is always unsuccessful, as the transplanted part invariably becomes opaque.

The refractive error must be corrected, and the wearing of a stenopaic aperture is sometimes beneficial. The object of the latter is to exclude the opaque area, by which means the dazzling due to irregular refraction is prevented, only the transparent part of the cornea being brought into use for vision. Unfortunately, the scar which lends itself to such treatment is rarely encountered.

Displacement of the pupil, by excision of a small portion of the iris opposite a clear part of the cornea, offers often the only means of restoring vision in dense central opacities. Tattooing of the scar renders it less noticeable, and in some cases an improvement in vision follows, but there is a slight risk of introducing sepsis and causing cyclitis, however carefully it is performed.

Corneal opacities of non-inflammatory origin are the arcus senilis and zonular opacity. The latter occurs sometimes in old age, and most frequently in old blind eyes. It develops slowly, and commences on either side of the lower part of the cornea, gradually growing inwards towards the centre, and on examination with the corneal loupe it is found to be composed of grayish-white dots, lying just underneath the epithelium. These give to the surface of the cornea a roughened appearance, like shagreen.

Ectasia of the Cornea.—This is a bulging forward of the cornea, and may be of inflammatory or non-inflammatory origin—

Non-inflammatory—keratoconus or conical cornea; keratoglobus.
Inflammatory—Staphyloma; keratectasia.

Keratoconus or Conical Cornea.—This consists of a bulging forwards of the central portion of the cornea beyond its normal curvature, assuming the form of an obtuse transparent cone. The periphery becomes more flattened, and the central part gradually increases in curvature, remaining transparent at first, but later, at the apex of the cone, a slight turbidity develops, which becomes more manifest as the disease progresses. It commonly develops about the age of fifteen to twenty, and is more frequent in young women than men, but it is only rarely met with, the average at a large London eye hospital being one in 7,000 patients. The condition usually progresses for three or four years, and then remains stationary. Its advancement is not regular, but periods of sudden increase, in some cases as much as 3 D in a few weeks, followed by periods of quiescence, are characteristic of this affection. In most cases both eyes are attacked, the second one considerably later, even a year or more, than the first.

The symptoms are diminished visual acuity, and perhaps asthenopia may be complained of, the patient frequently volunteering the statement that near vision is good. In the later stages the conicity may be noted with the naked eye, by looking at the cornea from side to side, but not so in the early period, and unless the eye is systematically objectively examined in the routine method laid stress upon, the early stage of this disease may be mistaken for regular myopic astigmatism. On examining the corneal reflex, the corneal images will appear small and perhaps regular in the centre, but are displaced irregularly towards the periphery.

On transmitting light into the fundus, a characteristic appearance is presented; centrally a dull glow is observed, which peripherally becomes considerably brighter, whilst between the two is a dark shadow of varying breadth. On rotating the mirror the shadow always moves round the centre of the pupil, never across it, no matter in which direction the mirror is rotated. By rotating the mirror in the direction of the moving shadow, that is circularly, a very characteristic appearance is presented, like a slow moving Catherine wheel. In these cases no point of reversal is revealed, and so retinoscopy does not help in determining the refractive error, but it enables the true nature of the affection to be detected. Besides the circular shadow, two others can frequently be discerned. In the periphery an emmetropic or low myopic shadow may be seen, and centrally there is observed the ill-defined shadow met with in high compound myopic astigmatism.

Ophthalmoscopically the vessels of the optic disc and the disc itself appear distorted, and the latter alters in shape and size, according to the portion of the cornea we are looking through. By the keratometer the reflected images are of various sizes, and cannot be brought into parallel lines, thus showing an irregular astigmatism of the cornea. There is a period in the early stages of the affection when even careful objective examination will only reveal some myopic astigmatism, and the true nature of the affection will only be suspected at the patient's subsequent visit, when an increase of the astigmatism will be revealed. This is always suspicious, and examination of the patient at short intervals is advisable, until time disproves or confirms one's suspicions.

Both naked eye and microscopical examination reveal a thinning of the cornea over the cone, this increasing gradually from the periphery to the apex, and at the latter a thin scar may represent all that remains of the cornea. This never ruptures, but some observers think that it admits of filtration of the aqueous, so accounting for the diminished ocular tension occasionally met with.

Widely divergent and conflicting views are held with regard to the cause of conical cornea, and, as these are purely theoretical, they merely demand enumeration: (1) General malnutrition; (2) inherent weakness and deficient firmness of the cornea; (3) defective embryological development; (4) chronic disease of Descemet's membrane: (5) increased intra-ocular pressure.

That treatment cannot cure the condition is evident, and it is doubtful whether non-operative treatment even retards its progress. Attention to general health and abstention from work necessitating much use of eyes is perhaps desirable, and also careful correction of the refractive error. Long-continued instillation of eserine is favoured by some surgeons. In spite of such treatment, the disease invariably progresses. Surgical treatment is sometimes performed with the view of arresting its development, and this aims at the substitution of a resistant cicatrix for the attenuated apex of the cone. The latter is destroyed either by cautery or by excision. The cicatrix, thus found, lies directly in front of the pupil, rendering necessary its displacement to one side by means of a small iridectomy before any acuity of vision is regained.

Keratoglobus.—The cornea and the whole of the eyeball becomes enlarged, and the condition is called bupthalmus, or ox's eye. It arises in childhood, and is caused by increased intra-ocular pressure.

Ectasias of Inflammatory Origin.

Staphyloma of Cornea.—This is a protuberant cicatrix, and is the result of a perforation of the cornea, in which a large portion of the latter has been destroyed. The iris then prolapses, and becomes covered with inflammatory exudation, which later cicatrises, and wholly or in part replaces the cornea. The resistive power of the cicatrix is less than that of the normal cornea, and hence bulging of the former takes place. A staphyloma may include the whole of the cornea or only a part of it.

Keratectasia is a protrusion of the cornea, and occurs when the latter has been weakened by a prior inflammation.

THE SCLERA.

Chapter VI.

ANATOMY.

The sclerotic invests the posterior five-sixths of the globe, and is composed of dense, pearly white, fibrous tissue, almost avascular in character, which together with the cornea, forms the fibrous envelope of the eye, whose shape is nearly that of a sphere, with a constriction at the corneo-scleral margin.

The sclera is thickest (about 1 mm.) posteriorly, and it gradually becomes thinner anteriorly, but the insertions of the recti muscles near the corneal margin cause a slight increase in thickness in this region. The fibres of connective tissue are united into bundles, which run in two main directions, one from before backwards—the meridional fibres—and the other, concentric with the cornea—the circular or equatorial fibres. Lymph spaces, with cells lining them, are found between the bundles of fibres. The histological structure of the sclera is thus something similar to that of the cornea, and at the corneo-scleral junction the fibrous tissue of the sclera passes continuously into that of the cornea, its most superficial fibres being inserted last of all. The two structures are dovetailed one into the other, and in the deeper part of this junction is a circular canal called the canal of Schlemm, which communicates externally with the scleral veins, and internally, through numerous small openings (ligamentum pectinatum), with the aqueous humor in the anterior chamber.

The outer surface of the sclera posteriorly is in contact with Tenon's capsule, a lymph space intervening between the two, whilst anteriorly it is covered by the conjunctiva, being separated from it by loose connective tissue called episcleral or subconjunctival tissue. The tendons of the ocular muscles are inserted into the sclera at varying distances (4 to 8 mm.) from the corneo-scleral margin.

The following blood vessels piece the sclera to enter the eye (Fig. 43):—

(*a*) Anteriorly, near the corneal margin, the anterior ciliary vessels.

(*b*) About the equator, the venæ vorticosæ.

(*c*) Posteriorly, the long and short posterior ciliary arteries.

At the site of the optic nerve the sclera becomes split up into a network of interlacing bundles, called the lamina cribrosa, leaving a series of fine sieve-like apertures, through which the bundles of the optic nerve pass into the eye.

The sclera is only loosely attached to the sublying choroid by an irregular meshwork of fine connective tissue, except at the site of the optic nerve and over the region of the ciliary muscle, and this network forms a considerable lymph space called the perichoroidal space. The sclera, though traversed by vessels and nerves, which penetrate into the interior of the eye, has of itself very few vessels, and on account of this poor vascular supply it is rarely the source of a primary acute inflammation.

PATHOLOGY.

Inflammation of the sclera is called scleritis, and that of the episclera is known as episcleritis.

Episcleritis.—This is an inflammation of that loose connective tissue which connects the sclera to the conjunctiva. It usually shows itself as an ill-defined swelling on the outer side of the sclera, immediately behind the zone corresponding to the ciliary body. Over the swelling the conjunctival vessels are dilated, and also there is a deep-lying dusky or violet area, due to congestion of the sclerotic coat. The former vessels move with the conjunctiva, but not the latter. On palpation the swelling is felt to be hard and nodular, and is very sensitive to the touch. Except at the site of the nodule, the eye may be perfectly free from redness (injection). Over the swelling there is often to be seen a translucent whitish patch, resembling a conjunctival phlyctenule, and supposed to be due to some obstruction in the lymphatic vessels.

The symptoms vary greatly; often, only slight discomfort is complained of, though occasionally very severe pain is present, depriving the patient of sleep. Its onset is sudden, and its duration variable, often lasting from two to five weeks, the nodule gradually flattening and becoming paler. Occasionally it leaves no trace behind, though more frequently a slate-coloured patch is left over the affected area, but otherwise the eye is normal.

Episcleritis is very liable to recur, often involving the entire circumcorneal area before the disease exhausts itself. It is sometimes associated with rheumatism, and treatment consists chiefly in the search for, and eradication of, the cause, and the application of hot fomentations. Internal remedies do not seem to have much influence on the affection.

Scleritis.—This is an inflammation involving the sclera proper, and it chiefly affects the ciliary region of the sclerotic. There is an ill-defined swelling, accompanied by conjunctival injection, the sclera also showing an extensive bluish-red injection. Both the swelling and redness are not so localised as in episcleritis. The inflamed portion never forms an ulcer, but the sclera is thinned, and no longer able to resist the normal intra-ocular pressure, consequently a bulging appears over the site of the disease, This is called an ectasia. In scleritis the deeper portions of the eye (the iris, ciliary body and choroid) are also affected, so it is much more serious than the superficial form (episcleritis). No special train of symp-

toms other than objective signs can be ascribed to scleritis, but an ill-defined swelling of a purplish hue, outside the corneo-scleral margin, and generally surrounding it, together with perhaps slight iritis and cyclitis, form a clinical picture hardly likely to be confused with that of any other disease.

The cause, like that of iritis and cyclitis, lies in the poisons produced by microbes, and the treatment lies in its elimination, by attacking the source of these poisons. Local treatment, as hot fomentations and atropine, where iritis is present, is also applied.

Ectasia, or Staphyloma of the Sclera.—This is a protrusion or bulging of the sclera, involving either a portion of it (partial ectasia) or the whole (total ectasia).

Partial Ectasia.—This appears as a localised protrusion, of a bluish-black colour, owing to the choroidal pigment shining through the attenuated sclera. This is so thin over the area as to be readily dimpled by the point of any blunt object, such as a match.

Various forms of ectasia, or staphyloma, are distinguished according to their situation:—

(*a*) Anterior or ciliary staphyloma.

(*b*) Equatorial staphyloma.

(*c*) Posterior staphyloma.

Anterior Staphyloma appears as a series of grape-like bulgings around the ciliary region, the sclera being so thin as to admit of the pigment of the ciliary processes being seen. This condition may be limited to a part, or involve the whole, of the sclera in that region.

Equatorial Staphyloma is a protrusion behind the ciliary region in the neighbourhood of the equator of the eyeball. It is generally only noticed when the eye is rotated strongly either inwards or outwards.

Posterior Staphyloma is a protrusion of the sclera at the posterior pole of the eye, and is the most common cause of high myopia, owing to the elongation of the eyeball along its sagittal axis.

Though the cornea and anterior half of the eye have attained their full development about the fifth year, the eyeball does not reach its full size until about the seventeenth year of life (puberty). During the intervening years the axial growth of the eye takes place solely behind the equator, by a retrocession of the posterior pole, this continuing until the eyeball is of the normal physiological dimensions (emmetropia). Anything which tends to diminish the resistive power of the young and comparatively soft sclera will cause an excessive yielding of the unsupported posterior pole of the eye before the normal intra-ocular pressure, and so produce an increased axial length of the globe. The increased length (myopia) was supposed to be due to the creation of an increased intra-ocular pressure, brought about by excessive action of the external and internal eye muscles, this being greater

than the coats of the eyeball could withstand. If this were so, the lamina cribrosa, being the weakest spot in the eyeball, would be driven backwards, as it is in glaucoma, but in myopia such never occurs. Henderson has experimentally proved that under normal conditions the pressure within the eyeball, and that within the optic nerve sheaths and brain, are exactly the same under all ordinary conditions, and hence the lamina cribrosa has normally to withstand no pressure at all, and so always preserves its relationship to the adjacent coats. If, however, the intra-ocular pressure be raised, as in glaucoma, the lamina cribrosa is pushed backwards, whilst if the intra-cranial pressure be raised, as in brain tumor (choked disc), it is pushed forwards.

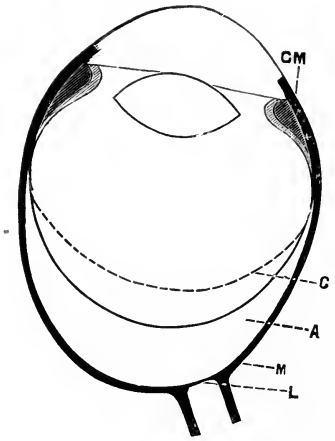


Fig. 39.

Diagram illustrating development of the myopic globe.

The anterior half is fully developed by the fifth year of life, but the axial length is short, and so the eye is hypermetropic, though at the age of puberty the eye has attained its normal axial length. If the posterior expansion occurs too rapidly and excessively, myopia is produced. The lamina cribrosa retains its position, as the pressure in the eye and brain are equal.

CM Ciliary muscle. *C* Position for child of six years, *A* Adult, *M* Myope. *L* Is the lamina cribrosa

In view of Henderson's experiments, it is more probable that myopia arises from a less firm and weakened sclera being unable to withstand the ordinary intra-ocular pressure, rather than due to an increased intra-ocular pressure.

The limits of the posterior staphyloma can be often defined ophthalmoscopically, as at some distance from the papilla, running concentrically with it, the retinal vessels will be seen by parallactic displacement to dip down over the edge of the staphyloma.

THE IRIS AND CILIARY BODY.

Chapter VII.

ANATOMY.

The iris arises from the anterior surface of the ciliary body, and is a contractile diaphragm, dividing the space between the cornea and lens into two, viz., the anterior and posterior, chambers. These are filled by the aqueous fluid, the chambers communicating with each other by a central aperture in the iris diaphragm, called the pupil. The iris is placed immediately in front of the lens, its pupillary margin lying in actual contact with the lens capsule, and so the posterior chamber is represented only by the shallow space existing between the extra-pupillary portion of the iris and the shelving peripheral surface of the lens. By lying upon the lens, the iris obtains a firm support, and when the former is absent, or has lost contact with the iris, the latter is seen to tremble with movements of the eyeball. The iris forms a shallow cone, whose apex, directed forwards, is represented by the pupil, and the greater the advancement of the lens, the more prominent is the cone, whilst, if the lens be retracted or absent, the iris appears flat. In looking at the iris, either with the naked eye, or, better still, by focal illumination, delicate markings (so-called patterns of the iris) will be recognised. These are caused by elevations and depressions on its anterior surface. In the normal eye they are well defined and clear, but in an inflamed or atrophic iris they are blurred and indistinct, so forming an important sign in iritic affections. The markings consist chiefly of projecting ridges, caused by the blood vessels in the stroma radiating from the pupillary to the ciliary border. Near the pupillary margin a circular ridge —the circulus minor—is seen, which divides the iris into two zones, a

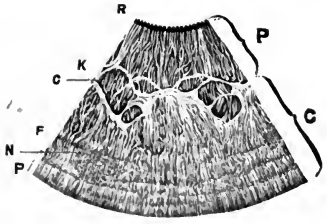


Fig. 40.

Anterior surface of the iris, magnified six times.
P Pupillary zone. *C* Ciliary zone. *R* Fringe of retinal pigment. *K* Lesser circle.
C Crypt. *F* Contraction groove. *N* Naevus. *P* Peripheral dark zone.

narrow pupillary, and a wide ciliary one. The former is of a different colour from the latter, being generally lighter. Along the circulus minor, depressions or crypts are easily observed, which are apertures leading into the tissue of the iris, so allowing of free communication between it and the anterior chamber.

The iris consists of a vascular and pigmented stroma of connective tissue, containing also two sets of specialised fibres. Covering it anteriorly is a layer of epithelial cells, continuous with those lining the posterior surface of the cornea, whilst posteriorly the iris is lined by the pigment epithelium, continuous with that covering the ciliary body, and which extends as far forwards as the margin of the pupil. The pigmentary membrane represents the continuation of the retina to its termination at the pupillary margin, and consists of two layers, the anterior representing the pigment epithelium of the retina, the posterior the retina proper. The stroma of the iris consists chiefly of numerous vessels running from the ciliary to the pupillary margin, and surrounding them is a network of cellular tissue, in which many pigment cells are found. Also in the stroma are two sets of specialised fibres, one being arranged concentrically around the pupil, and consisting of a layer of unstriped muscular tissue forming the sphincter of the pupil, whilst the other set consists of a layer of elastic and muscular fibres radiating towards the periphery, forming the dilator pupillæ. Some authorities deny the existence of the muscular fibres in the dilating apparatus of the iris.

The colour of the iris depends upon the amount of pigment in the stroma, as that in the posterior layer is more or less constant. When the stroma contains little, the retinal pigment shows through the thin iris, and appears blue, just as a dark background always appears blue when viewed through a more or less opaque medium. If the stroma is deficient in pigment, but fairly thick and compact, the iris appears grey; whilst if pigment abound in the stroma, then the iris appears brown. The iris is of unequal bulk, being thickest at its periphery, where it forms a broad attachment to

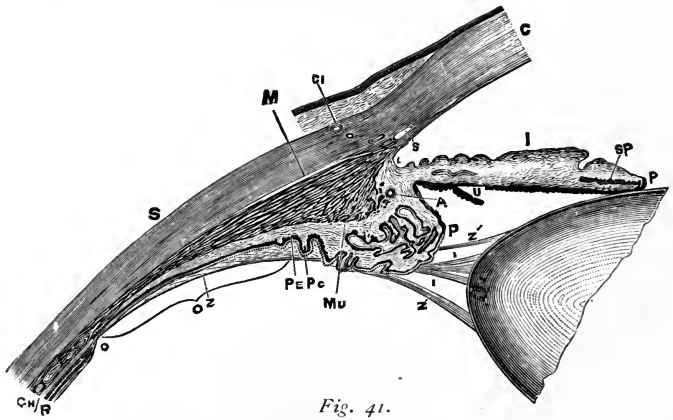


Fig. 41.

The ciliary region.

S Sclerotic. *C* Cornea. *R* Retina. *Ch* Choroid. *I* Iris. *s* Canal of schlemm. *P* Ciliary processes. *M* Longitudinal fibres of ciliary muscle. *Mu* Circular fibres of ciliary muscle. *L* Ligamentum pectinatum. *A* Circulus iridis major. *SP* Sphincter pupillae. *U* Uveal pigment lining iris (broken away at U) and rounding edge at P. *CI* Anterior ciliary vessels. *O* Flat portion of ciliary body. *O* Ora serrata. *Z Z'* Zonule of Zinn. *i* Canal of Petit. *Fe Pc* Layers forming the pars ciliaris retinae.

the ciliary body, and here it is separated from the cornea by a rounded space called the "angle of the anterior chamber." This space is traversed

by a loose-meshed stratum of connective tissue, known as the "ligamentum pectinatum," which is supposed to arise from the splitting of Descemet's membrane of the cornea. These meshes form a series of communicating channels called the "spaces of Fontana," which serve for the filtration of the aqueous fluid, passing from the anterior chamber into a venous channel or sinus, called the "canal of Schlemm," situated between the cornea, ciliary body and iris (Fig. 41).

The above views with regard to the angle of the anterior chamber have recently been strongly controverted by Henderson, who says that the ligamentum pectinatum iridis does not arise from the splitting up of Descemet's membrane, and is not a ligament of the iris, nor does it terminate in the root of the iris, but that it originates as a continuation of the inner lamellæ of the cornea, and for the most part forms the ligament of origin of the ciliary muscle. He states that it is, at birth, a cellular structure, which undergoes progressive sclerosis with advancing years, until it becomes entirely fibrous.

The aqueous humor not only escapes by Schlemm's canal, but also through the crypts of the iris into the iritic veins.

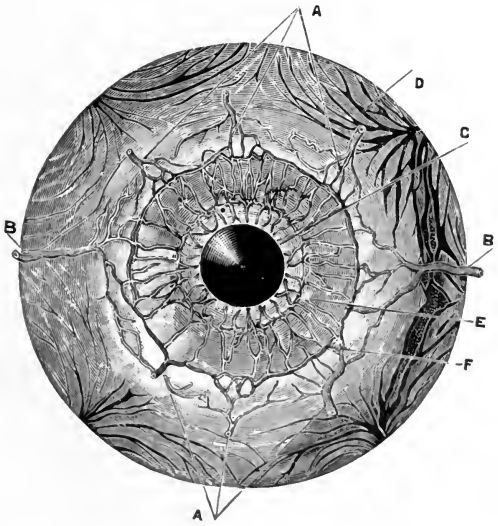


Fig. 42.

Blood vessels of iris and anterior part of choroid, viewed from the front.
A Anterior ciliary arteries. *B* Long ciliary arteries. *C* Pupil. *D* Veins of choroid. *E* Circulus minor. *F* Circulus major.

The arterial supply of the iris is furnished by the ciliary arteries, some of which run forward between the sclerotic and choroid, whilst others, the anterior ciliary arteries, pierce the sclerotic close to the corneal margin.

To congestion of the latter is due the characteristic pink zone which surrounds the cornea in inflammation of the iris and ciliary body (ciliary congestion). Upon the iris the arteries form two arterial circles, the one (circular iridis major) round the periphery, and the other (circulus iridis minor) round the pupil; the two being connected by numerous vessels (Fig. 42).

The Ciliary Body is the continuation forwards of the retina and choroid. Commencing at the line of the ora serrata (Fig. 41), it consists of an internal deeply pigmented part, which is thrown into a series of radiating folds (the ciliary processes), and an external non-pigmented part, consisting of unstriped muscle fibre (the ciliary muscle). The latter part forms the greater portion of the ciliary body. The ciliary processes, about seventy in number, radiate towards the lens, completely encircling it about the equator, being separated from it by a space—the circumlental space—which is traversed by the suspensory ligament of the lens, the zonule of Zinn. The processes are lined internally by a layer of non-pigment cells, and to the outer side of these is placed a layer of pigmented cells. These two layers represent the continuation forwards of the retina beyond the ora serrata, and are called the "pars ciliaris retinæ." The remaining portion of the ciliary processes consists of a connective tissue stroma, containing branched pigment cells, and an extraordinary number of blood vessels. The processes are supposed to secrete the fluid which nourishes the eye, and an inflammation of them (cyclitis) is always of serious moment. The outer part of the ciliary body is formed chiefly by the ciliary muscle, the latter being arranged in two layers. One of these runs meridionally, arising about the sclero corneal margin, and goes backwards to be inserted into the anterior portion of the choroid, whilst the other layer, situated more internally, runs circularly around the ciliary processes.

The *Aqueous Humor* is a limpid fluid, which normally contains a small amount of albumen. It fills the anterior and posterior chambers, and is chiefly secreted by the ciliary processes, and reaches first the posterior chamber, from which it passes through the pupil into the anterior chamber, making its exit from the eye by way of the ligamentum pectinatum and Schlemm's canal. The fluid is constantly and slowly secreted according to requirements, but when the aqueous escapes, as in perforating wounds of the cornea, it is produced again very rapidly, the anterior chamber being re-formed in a few minutes. The aqueous humor serves as a medium in which the iris can freely act, and it also supplies the nourishment to the lens and cornea.

Three systems of blood vessels exist in the eye: the conjunctival, retinal, and ciliary. The arteries of the ciliary system are as follows:—

(1) *The posterior ciliary arteries* enter the interior of the eye through the sclera posteriorly, most of them passing at once into the choroid. Two of them, however, one on either side, run between the choroid and sclera as far forwards as the ciliary muscle, where each divides into two branches that proceed in a direction concentric with the margin

of the cornea, encircling the latter, and giving off the arteries to the iris. These latter run in a radial manner from the ciliary to the pupillary margin, and shortly before they reach this they form, by anastomosis, a second and small vascular circle.

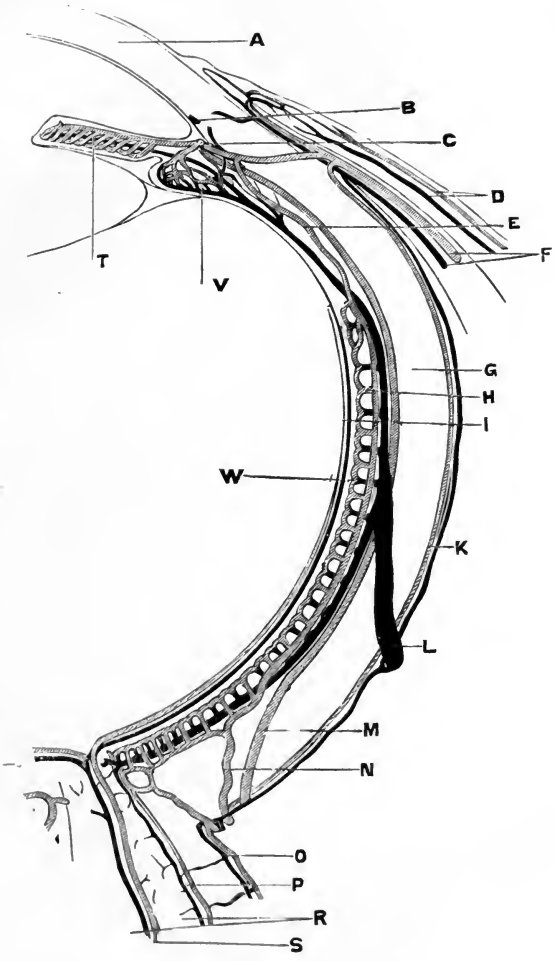


Fig. 43.

Diagram of circulation in the eye. The arteries are shaded, and the veins black. *A* Cornea. *B* Canal of Schlemm. *C* Circulus arteriosus major. *D* Conjunctional vessels. *E* Recurrent artery of choroid. *F* Anterior ciliary vessels. *G* Sclera. *H* Choroid. *I* Retina. *K* Suprascleral vessels. *L* Vena vorticosa. *M* Long posterior ciliary artery. *N* Short posterior ciliary artery. *O* & *P* Outer and inner vessels of the sheath. *R* Optic nerve. *S* Central artery and vein of retina. *T* Vessels of iris. *V* Vessels of ciliary process. *W* Capillaries of choroid.

(2) *The anterior ciliary arteries.* These, coming from the front, and arising from the arteries of the four recti muscles, perforate the sclera near the corneal margin, and anastomose with the circle formed by the two long posterior ciliary arteries.

The arrangement of the veins, which take the blood back to the heart, is quite different from that of the arteries. Most of the blood from the ciliary body and iris passes out of the eye by four large vessels, called venæ vorticosæ, which perforate the sclera in a very oblique direction, slightly behind the equator of the eyeball. Some of the blood from the iris and the ciliary muscle escapes by veins which pass directly out of the sclera, and which come into view beneath the conjunctiva near the margin of the cornea. These are called the anterior ciliary veins, and they correspond to the anterior ciliary arteries. They principally constitute the violet vessels which we see running backward beneath the conjunctiva in glaucoma and in ciliary injection.

THE PUPIL.

The iris performs two functions. Firstly, it controls the amount of light entering the eye (the less the illumination, the larger the pupil, and the greater the illumination, the smaller the pupil), thus preventing an intense light from injuring the retina. Secondly, it cuts off the marginal rays, which would, unless arrested, diminish the sharpness of the retinal image, owing to the difference in refraction of the periphery of the cornea and lens from that of the centre.

Contraction is produced by the sphincter pupillæ muscle—a layer of unstriped muscular fibres arranged concentrically around the pupil. The blood vessels of the iris, when distended, by broadening the iris, also diminish the pupillary aperture. The pupil is supplied by the third nerve as also is the ciliary muscle (the muscle of accommodation).

Dilatation is probably partly a muscular act and partly due to the inherent elasticity of the iris, owing to the presence of numerous elastic fibres in its posterior layers. Some authorities doubt the presence of a dilating muscle, whilst others assume that the dilatation of the pupil is wholly due to muscular effort. The muscle fibres are arranged in a radial manner, but are very thin, and the sympathetic nerve supplies them. Contraction of the blood vessels of the iris, as by cocaine, narrows it, and so increases the size of the pupil. Like all other sphincters in the body, that of the iris maintains a tonic contraction when at rest, as is exemplified by the contraction of the pupils during sleep.

The normal size of the pupil varies very much within the limits of health in different individuals, delicate and nervous children and myopes having generally very large pupils, whilst in elderly people and hypermetropes the aperture is generally small, as also in many cases of early spinal disease. Normally both pupils are of equal size, and any difference is due to some pathological condition.

The reaction of the pupil takes place involuntarily and unconsciously. It is either reflex, in which case the stimulus is transmitted from the brain to the nerves of the iris, as in an increase of illumination; or it is associated, as in the act of accommodation, when the pupillary fibres of the third nerve are set into action simultaneously with those supplying the ciliary muscle.

Reflex Movements.—The pupillary reflexes are three in number:—(1) Light reflex; (2) reflex on associated movements of the eyes; (3) reflex to sensory stimuli.

(1) *Light reflex.*—There are two distinct reflexes—(*a*) the direct, (*b*) the indirect or consensual light reflex.

(*a*) The direct light reflex consists in the alterations that take place in the size of the pupil, when, one eye being screened, the other is exposed to varying degrees of light. An increase of light causes an immediate contraction, and a diminution of light a dilatation. We see this if we close one eye of the patient, and then alternately shade and expose the other eye to daylight by moving the hand in front of the eye, or focal illumination may be used, especially in elderly people, where the reaction is not so sensitive. The response of the pupil, both as regards the range of movement and its rapidity, should be noted.

(*b*) The indirect or consensual reflex of the pupil is the alteration that takes place in the pupil of the covered eye whilst the other is being tested for its response to direct light stimulation. In health the consensual reflex is equal to and synchronous with the direct reflex.

When an eye is completely blind the direct light reflex is lost, and the pupil is moderately dilated, assuming the position that a normal eye would have in the dark. At the same time, provided that there is no paralysis of the third nerve, or interference with the ciliary muscle, the pupil will react to consensual light. (Fig. 44.)

The light reflexes may be absent, though the eye has perception of light. This may be due to interference in the transmission of the impulse from the brain to the ciliary muscle, as in paralysis of the third nerve, or to the action of mydriatics, as atropine, etc., or it may be due to injury of the muscle, sometimes caused by a direct blow on the eye, or the pupil may be bound down, as the result of previous inflammatory attacks.

(2) *The reflex in associated movements.*—This always consists in a contraction of the pupil, and occurs—

(*a*) In convergence (acting with the internal recti);

(*b*) In accommodation (acting with the ciliary muscle).

The convergence reflex is best observed by directing the patient to look first into distance, then at one of the fingers held within a few inches of the eye. The contraction should be equal and synchronous, but is not so well marked as that due to light. It is dependent more upon convergence than accommodation, as it is well seen in high degrees of myopia, in which the accommodation is not employed. In a disease of the spine, due to syphilis, called locomotor ataxia, the pupils do not react to light, but do so to accommodation.

(3) *Reflex to sensory stimuli.*—Tickling of the skin in various parts of the body, and strong psychic stimuli, as fright, etc., produce dilatation of the pupil.

The application of certain drugs, as atropine, homatropine, cocaine, etc., dilate the pupil, these being known as mydriatics.

Mydriatics.—Atropine paralyses the sphincter and ciliary muscles, and hence dilatation of the pupil results, and also inability to see clearly close to. Its effects last for about a week. In practice 1 per cent. of atropine sulphate is most frequently employed, either in water or in the form of an ointment, or atropine may be dispensed in an oily form. The drug should be used with discretion, and only with young people, except in diseased conditions of the eye, as iritis, etc. Some children are very susceptible to atropine, this causing a reddened condition of lids and face, which, however, quickly subsides on discontinuance of the drug. It rarely causes symptoms of general poisoning, but they sometimes occur, and manifest themselves in dryness of throat, and sometimes delirium. The oily and ointment forms are the best, and least likely to cause any objectionable symptoms in children.

Duboisin, hyoscyamine and hyoscine are chiefly used as substitutes for atropine when that drug causes toxic symptoms.

Homatropine is a very useful mydriatic, as it dilates the pupil more quickly than atropine, and its effects wear off in from 24 to 48 hours. It is given in 1 per cent. solution, either in water or oil, and is often combined with cocaine hydrochloride (2 per cent.), as the addition of the latter results in a greater dilatation of the pupil.

Cocaine hydrochloride (2 per cent. in water) is a valuable mydriatic, for it does not abolish accommodation, as the above two do, and is particularly useful when a better view of the fundus is desired.

To prevent the possibility of toxic effects resulting from the use of the above drugs, the lower punctum should be drawn away from the eyeball, as the adverse symptoms arise from the fluid finding its way into the stomach *via* the nasal duct. The patient is directed to look up, and the lower lid is drawn outwards, the fluid being inserted between the eyeball and the lid. It may also be instilled by asking the patient to look down, and raising the upper lid, a drop of the lotion being placed on the sclera above the cornea. It is also advisable to order smoked glasses when giving atropine.

Myotics.—These are drugs which contract the pupil. That most commonly used is sulphate of eserine, and it is generally applied as a 1 per cent. solution. It not only contracts the sphincter iridis, but also the ciliary muscle. Its instillation is followed by pain and headache, and a feeling of great tension in the eye.

Other myotics used are the extract of Calabar bean and nitrate of pilocarpine.

Clinical Examination of Iris and Pupil.—Focal illumination is necessary, and the pupillary reaction, both to light and accommodation, must always be noted, as their absence is pathological. Also the position of pupil should be noted, as to whether centric or eccentric, and whether round or irregular in shape. The pattern of the iris should be observed, any blood vessels or lymph present being always an indication of past disease.

Abnormal condition of the Pupils.—They may be either abnormally dilated (mydriasis), or contracted (myosis), and one or both of them may be affected.

Mydriasis.—The causes may be within the eye (intraocular) or outside the eye (extraocular).

The following intraocular conditions may produce mydriasis :—

1. Increased or glaucomatous tension of the globe, by paralysing the ciliary nerves.
2. Laceration of the sphincter muscle of the iris by contusions or wounds.
3. Injuries involving the ciliary nerves, as by a dislocated lens.
4. Diseases of the choroid and retina, by lessening the sensibility to light.

The extraocular changes causing mydriasis are :—

1. Paralysis of the third nerve.
2. Disease of the optic nerve or tract, causing a diminished sensibility to light.
3. Irritation of the sympathetic nerve, generally caused by enlarged glands in the neck.
4. Nervous shock.

If the visual acuity can be improved by the pinhole disc, the cause of the dilatation is probably due to interference with the centrifugal fibres. (Fig. 44.)

THE OPTIC TRACTS AND PUPILLARY ACTIONS.

The field of vision common to the two eyes is composed of a right half G and a left half G_1. The former corresponds to the left halves of both retinæ L and L_1, the latter to the right halves R and R_1. The boundary between the two halves of the retina passes through the fovea centralis, at

which the visual line (V) drawn from the point of fixation F impinges on the retina. The optic nerve fibres from the right halves of the retina all pass into the right optic tract, and the fibres from the left halves into the left optic tract. This follows from the inner fibres of both optic nerves crossing over and passing to the other side, at the place called the optic chiasma. The optic nerve O extends from the eyeball to the chiasma; after that it is called the optic tract T T. Each optic tract contains fibres from both retinæ, and is continued up to the back or occipital part of the brain B, where the centre for vision is situated. Prior to reaching there it gives off fibres M, which go to the nucleus of the third nerve $K K_1$ in which are placed the centres for convergence, accommodation and pupillary reaction.

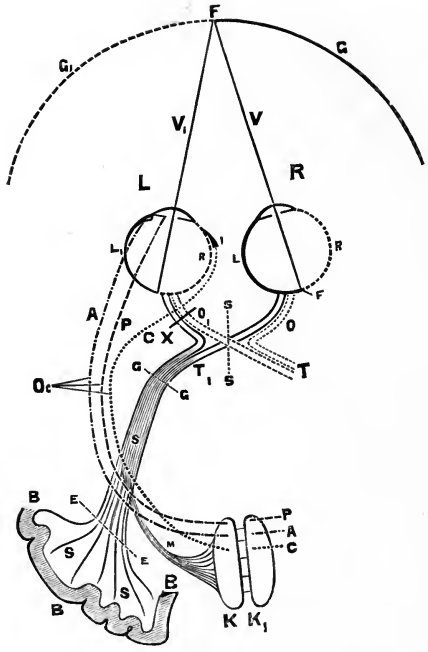


Fig. 44.

Schematic representation of optic tracts and pupillary actions. (*After* Fuchs.

Presuming there is a lesion in the optic tract at G G, preventing retinal impulses from reaching the brain, there would be no visual perception in the right half of the field, owing to the left halves of both retinæ being cut off from the brain, and this condition is called right hemiopia, but both pupils would react, owing to the right halves of the retinæ being sensitive. A lesion at X would cause total blindness of left eye, and loss of direct pupillary reflex, but the consensual reflex would be present, the impulse

travelling to the left optic tract from the left part of the right retina, and so on to the third nerve nucleus of the left side. Any interference with the third nerve, say at O c, would result in abolition of pupillary and accommodative actions, but vision would be more or less undisturbed.

A lesion at E E, above where the pupillary fibres are given off, would cause hemiopia, but pupillary reactions would be normal. A lesion at S S would destroy the function of the nasal parts of both retinæ, and so produce temporal hemiopia.

CONGENITAL ABNORMALITIES OF THE IRIS.

Coloboma of the Iris is a congenital deficiency of a portion of the iris, caused by non-closure of the anterior portion of the fœtal cleft, so that defect chiefly occurs in the lower median line (Fig. 45), and is often associated with a similar defect in the choroid or optic nerve sheath. There is often a family predisposition to this defect.

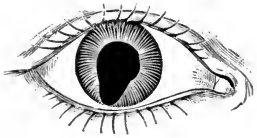


Fig. 45.
Coloboma of the iris.

Aniridia.—This is congenital absence of the iris, which may be entirely absent, or represented merely by a rudimentary stump attached to the ciliary processes. There is no interference with the secretion of the aqueous humor, this showing that the iris does not take a large part in the secreting process, as was previously held to be the case.

Iridodonesis or *Tremulous Iris.*—These terms are applied to an iris which trembles or vibrates on movement of the eye, a feature caused by loss of the support afforded by the lens. The absence of the latter may be either congenital or acquired, and is discussed more fully in Chapter VIII.

Variations in Colour.—The depth of colour of the iris is in proportion to the density and amount of pigment in the stroma, small localised patches of increased colour being physiological, and not uncommon.

In albinos (white-haired children), where there is a general lack of pigment, not only in the stroma, but also in the posterior pigmentary layer of the iris, and in the retina and choroid, the iris appears greyish white and translucent, allowing the red reflex of the fundus to shine through and give the eye a pinkish hue. Albinism is generally associated with nystagmus and a lowered visual acuity.

It is not unusual to note that one iris is of a different hue to the other, and in eyes blind from disease, especially in old glaucoma, the iris often assumes a greenish tinge.

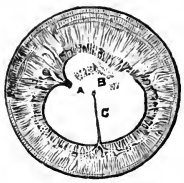


Fig. 46.

Diagram showing remains of pupillary membrane below, and two posterior synechial above, as seen under a mydriatic. *C* Remains of pupillary membrane, which arises from the anterior surface of the iris. There is no interference with dilatation of pupil at this point. *A* & *B* Old posterior synechiae, the result of a previous iritis. They spring from the edge of the iris, binding the latter down to the anterior capsule, and owing to their non-elasticity, preventing it from retracting when a mydriatic is instilled.

Capsular Pupillary Membrane.—In fœtal life a vascular membrane stretches across the pupil, which generally entirely disappears about two months before birth, but occasionally parts of it remain as greyish tags running from the iris to the capsule of the lens. These greatly resemble the posterior synechiæ remaining after iritis, but the latter spring from the pupillary margin of the iris, whilst the former spring from the anterior surface of the iris, about the circulus iridis minor. Sometimes the pupillary membrane persists as a few brown dots on the lens capsule. The pupillary membrane, owing to its elasticity, does not interfere with the dilatation of that part of the pupil to which it is attached.

Corectopia, or Displacement of the Pupil.—This is commonly seen in association with congenital displacement of the lens, and is due to the same cause, namely, a maldevelopment of the ciliary processes and suspensory ligament.

Discoria, or Alteration in the Shape of the Pupils.—The pupil may occasionally be oval instead of circular, caused sometimes by the traction of a tag of capsular pupillary membrane.

Aniscoria, or Inequality of Pupils.—This is practically always a pathological condition, though occasionally is occurs congenitally.

DISEASES OF THE IRIS AND CILIARY BODY.

When it is recalled that the iris, ciliary body and choroid closely resemble one another histologically, that their blood supply is identical, and that they form with each other a continuous membrane, it is rather surprising that any one of these three divisions of the uveal tract can become inflamed whilst the other two remain perfectly healthy. Yet this is

not unfrequently the case, although it is more common for the iris and ciliary body to be simultaneously affected. An inflammation of the iris is called iritis, and of the ciliary body cyclitis, and when both are involved it is called irido cyclitis. It is advisable to describe the symptoms and course of iritis and cyclitis separately, and later to paint the clinical picture of the two combined. Clinically we cannot always know whether only one or more divisions of the uveal tract are involved, but in every severe case of iritis more or less cyclitis is always present, whilst in slight iritis there is generally no cyclitis.

Iritis.—In iritis the severity of the symptoms bears a direct relationship to the intensity of the inflammation, and all degrees of the latter are met with, from a slight congestion of the iris, in which the blood vessels are dilated and the pupil contracted, but in which no exudate or lymph appears on the iris, to a very severe inflammation, resulting in the formation of pus (hypopyon) in the anterior chamber.

Hyperæmia, or congestion of the iris, occurs secondarily to some corneal or conjunctival affection, especially in the case of a foreign body in the conjunctival sac, or a corneal ulcer. The symptoms are those of the exciting affection, the pupil is contracted, and reacts sluggishly to light, but dilates regularly on the instillation of a mydriatic. The iris is also slightly discoloured, most noticeable when compared with that of the other eye. Some little ciliary injection around the corneal margin is frequently present. In this condition the blood vessels of the iris are merely dilated, owing to some reflex irritant, but no lymph is poured out of the vessels into the subjacent tissues, and the absence or presence of this lymph or exudate always distinguishes a hyperæmia from an inflammation, whatever part of the body is affected.

Two degrees of iritis are met with clinically—acute and chronic.

(1) *Acute Iritis.*—The degree of pain in iritis is very variable (depending to some extent upon the cause of the iritis). In gonorrhœal iritis it is very severe, but in syphilitic it is only slight. The pain is of a neuralgic character, either in the eye or around the brow, extending over the side of the head or down the face.

Intolerance to light is not usually a marked feature, though some photophobia is generally present, yet it is never so marked a feature as that intense dread of light so characteristic of some corneal affections. There is always considerable impairment of vision, which increases as the disease advances, and arises from turbidity of the aqueous, caused by the lymph, exuded from the iris, becoming deposited on the capsule of the lens in the pupillary area. The power of accommodation is also frequently impaired, owing to extension of the inflammation to the ciliary body.

Lachrymation is a common symptom when much photophobia is present, but there is no gumming of the lids in the morning, which is such a prominent sign of conjunctivitis.

Clinical Signs.—In slight cases there is well-marked ciliary injection, distinguished as a pink or pale violet zone around the cornea, in which the separate vessels cannot be seen, but in the more severe cases much conjunctival injection will also be present. (Plate II.)

By focal illumination the cornea will, at the first glance, appear hazy, but this is due to turbidity of the aqueous humor. It is in the iris, of course, that the changes are most marked, and a discolouration, a loss of lustre, and an indistinctness of the pattern will at once be recognised. The loss of lustre and of distinctness of pattern are due to the presence of lymph, both in the stroma and on the surface of the iris, and to cloudiness of the aqueous humor. The change in colour, a blue iris becoming greenish, and a brown one yellowish, is due to hyperæmia of the iris, as well as to the presence of inflammatory products.

The pupil is contracted, and more or less inactive to light or accommodation. The impaired mobility and the contracted pupil are due to engorgement of the blood vessels of the iris, to spasm of the sphincter muscle, and to posterior synechiæ. Exudation of inflammatory products (lymph) is present in greater or less degree, and may be found on either surface of the iris, in the pupil, in the aqueous humor, and in the tissue of the iris. The lymph or exudate is a thick, gummy fluid, and causes adhesions to form between the iris and the anterior capsule of the lens, generally only at the pupillary margin, these adhesions being called *posterior synechiæ*. The presence of posterior synechiæ is ascertained by observing the reaction of the pupil when intense and weak light are alternately thrown upon the eye, the pupil dilating only at those places where there are no synechiæ. The instillation of a mydriatic brings out this fact more clearly.

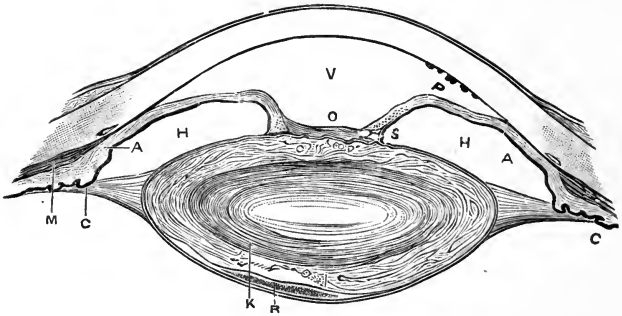


Fig. 47.

Seclusion and occlusion of the pupil, showing "iris bombé."

The iris is adherent by its entire pupillary margin, but is elsewhere pushed forward. The posterior chamber, *H*, is thus deeper; the anterior, *V*, shallower, especially at the periphery, where the root of the iris, *A*, is pressed against the cornea by the increase of tension. In consequence of traction on the iris its pigment is separating at *S*, to be left upon the lens capsule. The pupil is closed by an exudate membrane, *O*, by the shrinking of which the anterior capsule is thrown into folds. In the lower part of the anterior chamber there is matter, *P*, precipitated upon the posterior surface of the cornea. In consequence of the increase of tension, both the ciliary processes, *C*, and the ciliary muscle, *M*, are atrophic and flattened. The cortex of the lens has undergone cataractous disintegration, and at *R* is separated from the capsule by liquor Morgagni, the nucleus, *K*, of the lens being unaltered.

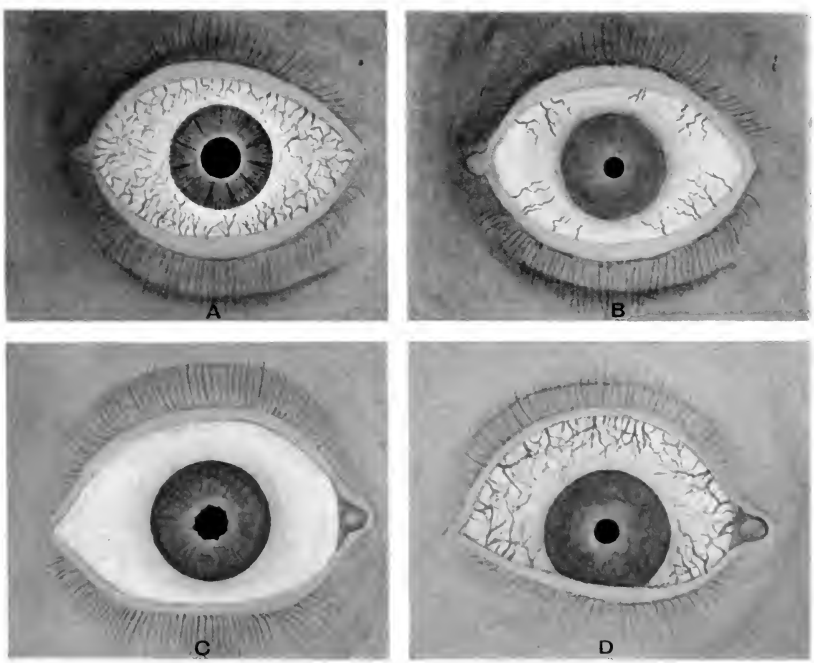


PLATE II.

A.—CONJUNCTIVITIS.

Note.—Redness less at corneal margin, vessels branch and are tortuous. Cornea is clear, pupil normal, and pattern of iris well marked.

B.—CILIARY INJECTION IN CHRONIC IRITIS.

Note.—Redness at corneal margin, and pale in tint, the vessels themselves not being seen. Iris indistinct, pupil contracted

C.—CHRONIC IRITIS.

Note.—Slight redness at corneal margin, absence of conjunc ival injection. Pattern of iris ill defined, pupil irregular.

D.—ACUTE IRITIS.

Note.—Conjunctival and ciliary redness. Pattern of iris obscured, pupil contracted.

Sometimes the entire pupillary margin becomes adherent (seclusio pupillæ), and then the posterior chamber is completely shut off from the anterior, so preventing escape of aqueous into it. As a result, glaucoma (increase of tension) supervenes, and the iris, being attached now at the pupillary as well as the ciliary margin, becomes bowed forwards between those attachments by the continuously increasing fluid in the posterior chamber, and this condition is termed "iris bombé" (Fig. 48). In recurrent attacks of slight acute iritis, or in chronic iritis, it is important to observe how much of the pupillary edge of the iris is bound down, and where nearly the whole of it is involved an iridectomy (removal of part of the iris) must be undertaken when the eye is quiet, in order to prevent the incidence of iris bombé and glaucoma, which cause a complete and permanent destruction of vision in a few hours. The iridectomy allows of the escape of aqueous from the posterior to the anterior chamber, and its egress from the eye through the angle of the cornea. If the area of the pupil be filled with exudation, the condition is known as occlusio pupillæ, which is generally associated with seclusio pupillæ. In the more severe cases of iritis the exudate more or less fills the anterior chamber, looking like matter or pus, and this condition is called hypopyon.

Opacities in the choroid are frequently present, owing to the involvement of the ciliary body, and keratitis punctata (see cyclitis) will be observed on the back of the cornea.

Beginners are very liable to confuse iritis with conjunctivitis, and below are tabled the chief points of difference (Plate II.):—

Conjunctivitis.	*Iritis.*
Pain, as if a foreign body were in the eye.	Pain of a neuralgic character, commonly referred to brow.
Lids gummed together in the morning, and mucopurulent discharge is present in the conjunctival sac.	No gumming of lids, no discharge present in sac.
Conjunctival injection present.	Ciliary injection is chiefly present. In severe cases, also conjunctival injection.
Cornea clear.	Cornea appears hazy, owing to turbidity of aqueous humor.
Iris normal, and pattern well marked.	Iris discolored, pattern indistinct.
Pupils active and normal.	Pupils contracted and only slightly active, posterior synechiae present.
Tension normal.	Tension normal.

Cause of Iritis.—It may be a primary disease, or it may be secondary to an inflammation of one or other of the coats of the eye, as a corneal ulcer (secondary iritis).

Primary Iritis is a blood infection, by which is meant that the poison causing the iritis is carried to the iris by the blood.

Rheumatism and gout very rarely, if ever, cause iritis, though until recently they were mentioned as frequent factors in the cause of this disease. The source of the poison lies generally in the collection of pus (matter) in some part of the body, especially under the gums, around the teeth (called Riggs' disease), or in the nasal sinuses (most commonly the sphenoidal), in which the patient often states he has a chronic catarrh, a condition which practically does not exist. The pus may also be in an abscess of the ear, and in women breast abscesses and infection of the genital organs are fruitful sources of the poison. Probably auto-intoxication from the intestine occasionally causes the condition.

Gonorrhœa is a common cause, and the attack is frequently very painful and severe. Syphilis commonly causes it, and it is then characterised by a peculiar tendency to the formation of nodules—perhaps as large as millet seeds—along the margin of the iris. Pain is only slight in syphilitic cases. General infections, such as pneumonia, typhoid and influenza, occasionally give rise to iritis.

Prognosis.—The length of duration of an attack cannot be foretold at the outset, as it depends largely upon whether we are able to determine and eradicate the source of the poison. If not, recurrences are the rule, but fortunately, in the large majority of cases, such determination is possible, but it involves examination of other cavities of the body, especially that of the nose. The presence of synechiæ was formerly thought to increase the tendency to recurrence, and various operations were devised and practised for the excision of these adhesions, but they have been completely abandoned, as the presence or absence of synechiæ does not influence the tendency to other attacks.

Treatment.—For the attack, hot fomentations of boric acid, and, in the severe cases, leeches are applied to the temple and behind the ears, and atropine is instilled frequently into the eye until the pupil is dilated. To prevent further attacks, the source of the poison must be eliminated. Dark protective glasses should be worn during the attack, and in very severe cases the patient may have to be confined to a dark room or to bed.

Chronic Iritis.—The symptoms are similar to those of acute, but less intense; generally only slight pain, chiefly of a neuralgic character, and intolerance to light, are complained of. The visual acuity may be more or less normal. This condition can only be diagnosed on examination of the iris and pupil. Slight ciliary injection is generally present.

The pupil will be slightly contracted and irregular, and will react unequally to light, the part not bound down to the iris only reacting to the varied illumination. The iris may be slightly discoloured, the pattern obscured, and blood vessels may be seen running over the surface—always a pathological phenomenon. At some part of the edge of the pupil exudate will be observed as a small whitish spot, or in the pupillary area brown spots of pigment may be seen, these representing spots where former synechiæ existed, and which had been ruptured, leaving a little of the pigment from the posterior layer of the iris upon the capsule.

In the formation of posterior synechiæ, it is not the stroma of the iris, but the layer of retinal pigment covering its posterior surface, which becomes adherent to the capsule of the lens, and when rupture of a synechia occurs, the line of severance is that between the posterior retinal pigment layer and the rest of the iris, owing to the loose attachment of the former to the latter, and not between the posterior retinal pigment layer and the exudate. On instillation of a mydriatic the irregularity of the pupil and the synechiæ will be brought into greater prominence.

Inflammation of the Ciliary Body—Cyclitis.—In acute cases this is always complicated with iritis, and the clinical picture described for that applies to this condition.

Chronic Cyclitis, often associated with chronic iritis, is an insidious and more or less painless disease, and the ciliary body, as the result of the inflammation, produces an increased secretion into the posterior chamber. This secretion is more viscid than the ordinary aqueous humor, owing to its containing a greater amount of albumen.

Symptoms.—The earliest symptoms are slight ciliary redness, generally more marked at one spot, accompanied by lachrymation, and sometimes a feeling as if the eyes were too full. In the early stages, and even later, there is little interference with visual acuity.

Clinical Signs.—The slight ciliary redness at once points to a pathological condition, and on examination by focal illumination the cornea will appear transparent and normal, but the anterior chamber is deeper than usual, owing to hypersecretion of the aqueous. The characteristically distinctive sign of cyclitis is the deposition of punctate fibrinous particles upon the back of the cornea (Descemet's membrane), called keratitis punctata, but more commonly spoken of as K.P. (Fig. 32). These particles are generally round in form, of a brownish hue, and arranged in the form of a triangle, with the base downwards, this peculiar shape being doubtless due to gravity, for at first, on leaving the ciliary body, they are suspended in the aqueous, but by virtue of centrifugal force caused by the rotation of the eyes and head, they are thrown against and adhere to the posterior surface of the cornea, and in so doing they arrange themselves according to weight, the largest and heaviest being lowest down.

The K.P. are particles containing pigment cells derived from the ciliary body, but sometimes they are only fibrinous in nature (like exudate), and then they appear greyish or white instead of brown. These deposits are easily overlooked, because they are so minute, and can only be seen by focal illumination and a strong magnifying glass, such as a corneal loupe, or by a + 20 D or + 30 D behind the ophthalmoscopic mirror. Their shape, colour and arrangement are so peculiar as to render confusion with any other condition, in a typical case, impossible. Occasionally they may appear singly, or scattered irregularly over the back of the cornea, or they appear as large white spots, looking, to the naked eye, like a deposit of mutton fat. When complicated with iritis, the usual changes in the iris will also be

noted. In the later stages of cyclitis slight vitreous opacities (like dust) will be detected in the vitreous, but only by the use of the plane mirror and a low illumination.

Cyclitis often occurs in middle-aged women, and occasionally in men, and the causal factor is, as in iritis, the absorption of toxic products caused by microbes. The recognition of this disease in its early stage is important, and, where slight ciliary congestion is present, even when visual acuity is normal, the pupil, iris and back of cornea should always be carefully examined, in order to exclude chronic cyclitis or irido cyclitis. This disease is probably the one most frequently overlooked by opticians, who really ought to have no difficulty in recognising it.

Treatment.—This is directed to the removal of the cause, and the application of hot fomentations to the eye. When increase of tension takes place it is occasionally advisable to allow some of the aqueous to escape from the anterior chamber by an incision in the periphery of the cornea. This is called a paracentesis of the anterior chamber.

Irido-cyclitis.—This presents the symptoms and clinical characteristics of both iritis and cyclitis, and the diagnosis of it is made in the same manner. Clinically K.P. is noted, together with discolouration and indistinctness of pattern of the iris, and contraction and slight activity of the pupils.

INJURIES OF IRIS AND CILIARY BODY.

Foreign Bodies.—These, when of small size, such as bits of steel or iron, may perforate the cornea and become imbedded in the iris or lens (if in the latter it becomes gradually opaque). The puncture in the cornea rapidly closes, and perhaps hardly any aqueous humor is lost. It is generally advisable to remove the foreign body without delay, using the large electro magnet when the foreign body is of a metallic nature.

Hyphæma, or Hæmorrhage into the Anterior Chamber, is the most common form of intra-ocular hæmorrhage, and the least serious to the eye. In amount it may vary from a few drops of blood to a complete filling of the anterior chamber. The hæmorrhage is usually caused by rupture of one of the superficial vessels of the iris, or by a separation of a portion of the iris from the ciliary body (coredialysis). The blood sinks to the bottom of the anterior chamber, quickly coagulates, and is recognised as a reddish mass situated in the lower part of the chamber. The blood is fairly rapidly absorbed, and where there is no external wound of the eye no serious consequences result. Treatment consists in cold applications to the eye, and if any sign of iritis supervenes the use of atropine is indicated.

Iridodialysis or Coredialysis.—This is a separation of the iris from its ciliary border, by which a new pupil is frequently formed. It is generally caused by a smart blow on the eye, such as the cork from a bottle of soda

water, or an accidental blow from an elbow. The separation of the iris from its ciliary connection is followed by free hæmorrhage into the anterior chamber, often completely occluding it. When the hæmorrhage is absorbed

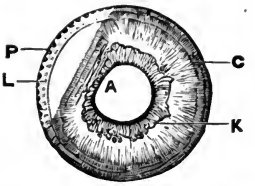


Fig. 48.

Iridodialysis.

The pupillary margin opposite the detached area is straight, and the rounded shape of the pupil is lost. In the interval between the edge of the torn iris and the cornea may be seen the margin of the lens, *L*. *P* Represents the apices of the ciliary processes, the fine radiating lines between the two representing the zonule of Zinn. *K* Is the circulus iridis minor, and *C* the contraction furrows of the iris.

there is found at the ciliary margin of the iris a black crescent, corresponding to the area of separation of the iris from the ciliary body. The separated edge of the iris is straight, and its pupillary border does not react to light, owing to rupture of the ciliary nerve, hence the pupil is not circular in shape. The sight is but little affected by iridodialysis, but monocular diplopia occurs, unless the object be accurately focussed.

Laceration or Rupture of the Sphincter Iridis.—This occurs also as the result of severe blows. The pupil remains fairly dilated and more or less immobile, and there may be recognised after a careful examination one or two torn parts along the pupillary border. Slight rupture of the sphincter is the commonest cause of a monocular dilated pupil. Occasionally the ciliary muscle is also paralysed or weakened, states recognised by a diminution of the amplitude of accommodation.

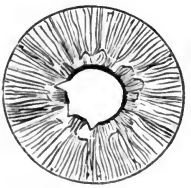


Fig. 49.

Radial laceration of the iris. Situated below are slight lacerations involving the pupillary border, as evidenced by the notches in the dilated pupil.

Prolapse of the Iris.—A condition caused by a penetrating wound of the cornea, especially if situated near the corneal margin. It is generally advisable to remove the prolapsed part of the iris.

Wounds involving the ciliary region are especially dangerous, owing to the great liability of sympathetic inflammation occurring in the other eye. This is most commonly manifested as a chronic cyclitis, whose symptoms and diagnosis have been detailed above. Tumors and cysts of the eye are rare, but easily recognised. The treatment is operative.

DISORDERS OF MOTILITY OF THE IRIS.

The above manifest themselves in a diminished pupillary reaction, and in an alteration in the diameter of one pupil. When affecting one eye, such is easily noticeable, and any inequality in the size of the two pupils is always pathological. The pupil may be dilated (mydriasis) or contracted (myosis).

Mydriasis, affecting one eye, is nearly always due to interference with the third nerve or its centre. It may be caused by syphilis or diphtheria, by the instillation of a mydriatic, or by direct injury of the iris or ciliary muscle.

Myosis is often associated with spinal lesions and the instillation of myotics.

OPERATIONS UPON THE IRIS.

The removal of a porton of the iris is called an iridectomy, which may be performed for optical reasons, as when a central opacity of the cornea or lens exists. The new pupillary aperture is called a coloboma, and is narrow and small when made for securing improvement in vision. An iridectomy is also performed in glaucoma, in order to secure a freer exit for the aqueous. In those cases the coloboma is wide, and extends to the periphery of the iris. An iridectomy is also usually performed just previous to extracting the lens in the cataract operation.

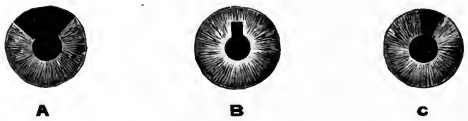


Fig. 50.

Showing three types of coloboma.

(*a*) *In glaucoma*, it is wide and extends to the periphery.

(*b*) *For optical reasons* it is narrow and does not extend to the edge of the iris.

(*c*) *In cataract extraction*, it is fairly narrow, and extends to the periphery.

THE CRYSTALLINE LENS.

Chapter VIII.

ANATOMY.

The crystalline lens is a transparent and colourless structure of lenticular shape and of a soft consistence, enclosed in a tight elastic membrane called the capsule. Its circumference is circular, is called the equator, and represents the line of junction of the anterior and posterior halves or surfaces. The posterior surface is more highly curved than the anterior, and the summit of curvature of each surface is respectively known as the anterior and posterior pole. The sagittal diameter (thickness of the lens) measures in the adult five millimetres, and the equatorial diameter nine millimetres.

The lens is imbedded in a shallow cup-shaped depression in the vitreous, known as the fossa patellaris; the hyaloid membrane separating the posterior capsule from the vitreous. The lens lies within the circle formed by the ciliary processes, but in such a way that its equator is distant about one-half millimetre from the apices of the processes, and this interspace is called the circumlental space. Anteriorly the lens is in contact over the pupillary area with the edge of the iris, but peripherally the latter structure is separated from the lens by a shallow space—the posterior chamber. The lens is held in position by the suspensory ligament called the zonule of Zinn, which consists of a series of delicate structureless fibres running from the ciliary processes to the equator, separating before reaching the latter, to form a small triangular lymph space known as the canal of Petit. The capsule of the lens is a homogeneous membrane, thicker upon its anterior than upon its posterior surface. Though clinically we speak of the anterior and posterior capsules, yet they are only differently situated parts of the same membrane. The anterior capsule is distinguished by having a single layer of cubical epithelial cells, from which the lens fibres originate.

The lens substance is composed of hexagonal fibres, united to each other by a soft, transparent substance. They begin and end upon the anterior and posterior surfaces of the lens, and are grouped in segments arranged in concentric layers, with their apices towards the poles, and can sometimes be recognised clinically as a stellate-shaped figure, radiating from the centre to the periphery, but this is most typically seen in the early stages of some senile cataracts.

The lens grows continuously throughout life by the uninterrupted production and elongation of the cubical cells which line the anterior capsule, and it increases more transversely than antero-posteriorly. If, after removing the capsule, the lens of an elderly man be crushed between the fingers, the softer peripheral masses separate, whilst the harder central portions remain uncrushed. The former is called the cortex and the latter the nucleus of the lens. They are not only different in consistence, but also in colour, the cortex being colourless, whilst the nucleus has a yellowish or brownish hue. The continuous production of lenticular

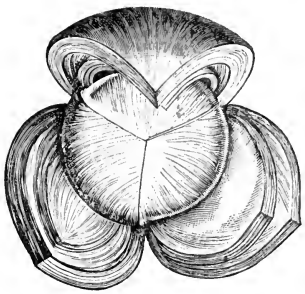


Fig. 51.

Lens hardened in formalin and dissected to show its concentric laminae (enlarged).

fibres causes compression of those most centrally situated, and, as a result, they become hardened, or sclerosed, and form the nucleus. Even in early life the lens has a hard core composed of the sclerosed fibres, and this gradually increases, so that in old people the nucleus occupies the greater portion of the lens. There are many individual differences in this respect, persons of the same age having different sized nuclei, this being of some practical importance in the operation for cataract.

The sclerosed portion of the lens is hard and rigid, and incapable of changing its form, so that the more advanced the sclerosis, the less able is the lens to make that alternating change in shape so essential to the act of accommodation. Another feature of the youthful lens is that it hardly reflects any light, but in later years, when the nucleus is dense and large, it gives by focal illumination a greyish or yellowish reflex, which is often mistaken for cataract, but by transmitted light no opacity is discernible. The lens is avascular, and nourishment is probably supplied by the ciliary body and the anterior portion of the choroid, such nourishment entering at the equator, and later emptying itself into the anterior and posterior chambers.

DEVELOPMENT OF THE LENS.

In its early stage the lens consists of a solid rounded mass of cells derived from the epiblast. This later is transformed into a hollow vesicle lined by a single layer of epithelial cells, and enclosed in a thin elastic

membrane (lens capsule). It is surrounded by a vascular capsule (pupillary membrane), supplied by the anterior ciliary vessels and the hyaloid artery, the latter arising from the central artery of the disc, and running forward through the vitreous to the lens capsule. Normally this disappears about the seventh month, but it may persist in its entirety throughout life, and offer no serious obstacle to vision, or the greater part may disappear, leaving a stalk attached either to the disc or posterior capsule, and easily recognisable ophthalmoscopically.

The lens fibres are formed by the cells lining the posterior surface of the capsule growing forward to fill up the cavity, thus forming a solid body. Hence, when the lens is fully developed (at birth) the posterior capsule has no lining cells, since they have formed the lens fibres. Gradual development of the lens goes on throughout life by the proliferation of the cells lining the anterior capsule, but the lens does not increase in bulk to any extent, as the fibres become more closely packed, and lose some of their fluid, this constituting what is known as sclerosis. The older fibres—the central ones—are the first to sclerose, so accounting for the fact that the nuclear part of the lens is less translucent, and in old people reflects more light.

CONGENITAL ANOMALIES OF THE LENS.

Absence of the Lens—congenital Aphakia.—This is so rare as to leave a doubt whether it ever exists.

Coloboma of Lens.—A defect seen as a notch in the inferior border of the lens, and supposed to be due to arrested development of the zonule of Zinn. It is often associated with coloboma of the iris and choroid.

Fig. 52.

Congenital displacement of lens.

Congenital Displacement of Lens, or Ectopia lentis.—The lens is invariably displaced upwards, inclining either inwards or outwards. This is supposed to be due to congenital absence of the inferior zonular fibres allowing the superior fibres to draw the lens upwards. (Fig. 52.)

Lenticonus.—This is a very rare, usually congenital, anomaly of the lens, which presents a conical prominence upon its anterior or posterior surface, appearing as if a drop of oil were situated there.

OPACITIES OF LENS—CATARACT.

Any opacity of the lens is called a cataract, and we distinguish between those situated in the capsule (capsular cataract) and those in the lens substance (lenticular cataract). The causes of cataract are various, and are enumerated below :—

(1) Congenital cataract.—Present at birth, and due to mal-development.

(2) Infantile cataract.—Arising in early life as a lamellar cataract.

(3) Senile cataract.—Arising in old age, owing to interference with the nutrition of the lens.

(4) Traumatic cataract.—Any foreign body coming in contact with the lens renders that part liable to become opaque, but if the capsule be ruptured the whole lens generally becomes swollen and opaque, and if no nucleus be present (in children), the opaque fibres become more or less absorbed by the aqueous humor.

(5) Cataract due to constitutional diseases such as diabetes or albuminuria.

(6) Cataract secondary to some inflammatory or degenerative changes in the ciliary body or anterior part of the choroid.

Cataracts are clinically classified according to the situation of the opacity :—

(1) Capsular cataracts, in which the opacity is on or just beneath the capsule.

(2) Cortical caratact, in which all the cortex is indifferently involved.

(3) Perinuclear cataract, where the opacity is around the nucleus.

The symptoms of lenticular opacities consist in a disturbance of vision, the degree of which depends on the situation and extent of the opacity. Small, circumscribed, dense, opaque opacities, provided they do not occlude the pupillary opening, as, for example, anterior polar cataract, cause little or no interference with sight; but larger opacities considerably disturb vision, and often alarm the patient by the production of peculiar phenomena, as muscæ volitantes and polyopia. The appearance of muscæ volitantes consists in the patient noticing black spots in the field of vision, which, if caused by opacities of the lens, change their position *only* with movements of the eye, and hence always occupy the same spot in the feld of vision (in contradistinction to vitreous opacities, which alter their place irrespective of movement of the eye).

Polyopia monocularis consists in the patient seeing the same object double or multiple with one eye, and it arises from the many images thrown on to the retina by the optically irregular lens. Muscæ volitantes and polyopia only occur in the earlier stages of cataract. If the lenticular opacity be situated centrally, vision may be improved when the pupil is dilated, as in the twilight, whilst if placed peripherally vision will be better when the pupil is contracted, as in sunshine or under eserine.

Clinical Recognition.—No reliance can be placed upon focal illumination in the early stage of cataract, as all lenses in old people, owing to the large nucleus, reflect such a lot of light as to appear grey or opaque by oblique illumination, but in the latter cases, on transmitting light, no shadow is seen in the red reflex. In advanced cataracts, on the other hand, focal illumination shows white or dense grey striæ or spots.

By transmitted light the diagnosis and position of cataract are confirmed. A plane mirror and low illumination are preferable, and the opacities appear in the early cases as black dots or striæ, which stand out in contrast with the red hue of the pupil. In the advanced stages no red reflex is seen at all, but in these cases recognition is easy by the naked eye, even without focal illumination.

The position of the opacity is determined by transmitted light. The further behind the pupil the opacity lies, the greater and quicker is the movement of the shadow on turning the eyeball, the movement of the shadow being in the opposite direction to that of the eye.

Clinical Forms of Cataract.—Every opacity begins at some special spot in the lens, and it may remain permanently limited to this area (partial stationary cataract), or it may gradually spread over the whole lens, and lead to total cataract.

Fig. 53.

Anterior polar cataract. *A* By focal illumination. *B* Sectional view of lens.

(1) Capsular Cataracts.—These consist of opacities situated, not in the lens, but in its capsule. They are stationary, and are sub-divided, according to their position, into anterior and posterior capsular cataracts. Their recognition, as also that of partial stationary cataracts, is of some importance, as the treatment, when vision is not below $\frac{6}{18}$, is purely optical.

The clinical picture presented by these stationary cataracts is generally so distinctive as to render their discrimination from the earlier stages of progressive cataracts quite a simple matter.

(*a*) *Anterior Capsular Cataract.*—It appears as a small white dot in the pupillary area upon the anterior pole of the lens, and may be recognised by focal illumination as a whole circular opacity, or by transmitted light as a

black dot, which, owing to it being practically in the same place as the iris, remains stationary, or moves very slightly against any movement of the eyeball. This condition may be congenital or acquired. In the latter case it is caused by a perforation of the cornea in early childhood, generally the result of ulceration, and confirmation of the latter will be found in the scar on the cornea.

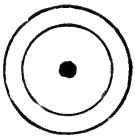


Fig. 54.
Anterior and posterior polar cataract, seen by transmitted light.

(*b*) *Posterior Polar Cataract.*—This consists of a small dot, similar to anterior capsular, but situated on the posterior capsule of the lens. It is only discovered by transmitted light appearing as a black round dot moving rapidly in the opposite direction from the movement of the eyeball. Posterior polar cataract is congenital in origin, and represents the remains of that part of the hyaloid artery attached to the posterior capsule. This artery runs in the fœtus from the retinal artery at the optic disc to the lens, and generally disappears two months before birth. Occasionally that part of the artery attached to the disc remains, and can be traced ophthalmoscopically, running forwards into the vitreous.

(2) Partial Stationary Cataracts Involving the Cortex.

(*a*) *Cataracta punctata.*—They appear as numerous dots of a greenish hue, scattered irregularly through the cortex, and are of congenital origin.

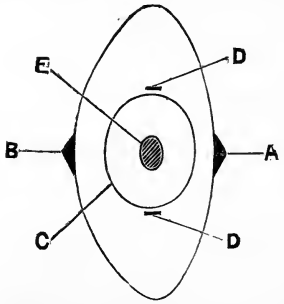


Fig. 55.
Diagrammatic representation of position of opacities.
A Anterior polar. *B* Posterior polar. *C* Lamellar, with its riders *D*. *E* Nuclear.

(*b*) *Cataracta fusiformis* is a spindle-shaped opacity running from the anterior to the posterior pole, also of congenital origin. These opacities in themselves cause only slight disturbance of vision, but the latter is often defective from other causes.

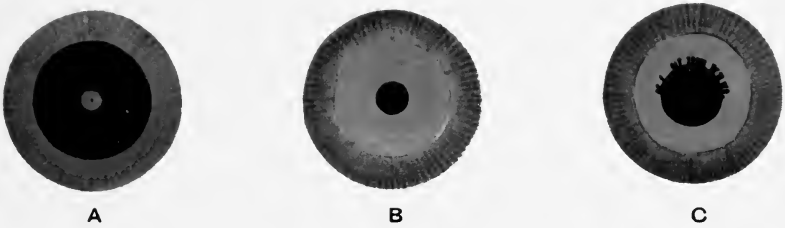


PLATE III.

A.—ANTERIOR POLAR OPACITY, as seen by focal illumination.

B.—ANTERIOR POLAR OPACITY, as seen by transmitted light.

C.—LAMELLAR CATARACT, as seen by transmitted light (pupil under atropine).

Note.—Opacity denser at margin than at centre. Riders only on upper half, the lower being the appearance without them. Between margin of opacity and edge of pupil is red reflex corresponding to transparent periphery of lens.

(*c*) *Lamellar or Perinuclear Cataract.*—This is the most frequent form of cataract in children, affects both eyes, and originates in early childhood, when there is a tendency to debility and rickets. The cataract presents a peculiar and characteristic appearance. With transmitted light it appears as a central dark disc, surrounded by the transparent, and therefore red and illumined, periphery part of the pupil. The darkness of the disc is greater near the edge than in the centre, so distinguishing it from an ordinary cataract, which is generally densest in the centre—at the nucleus. Along the outline of the opacity, which usually is sharply defined, small radiating jagged striæ, called riders, are occasionally seen, and they project from the margin of the cataract into the transparent periphery, like the spokes on the steering wheel of a ship. Plate III.) The density of lamellar cataract varies very considerably, so that in some cases a modified red reflex can be obtained throughout the entire opacity when viewed by transmitted light, but the central part is always the more transparent.

The interference with vision is proportionate to the density of the cataract, and in the slighter forms normal visual acuity may be obtained, whilst in the denser only $\frac{6}{36}$ is possible. Lamellar cataract does not progress after childhood.

Treatment.—When the visual acuity, with the refractive error corrected, equals $\frac{6}{12}$, no further treatment is advisable, but if the acuity is less than the standard, operative means should be resorted to. The latter may consist in an iridectomy (removal of part of the iris, so making a false pupil) opposite a clear portion of the lens, or removal of the lens by needling. This iridectomy is called an optical iridectomy, and only a small portion of the iris is removed, generally at the inner side. (Fig. 50.) In the latter operation a needle is introduced through the cornea into the lens substance, comminuting the latter, and bringing every portion in contact with the aqueous. The latter may absorb most of the broken down lens, but it is generally necessary to remove it. It takes from three to six days for the lens fibres to become opaque and macerated by the aqueous.

In lamellar cataract an optical iridectomy can only be performed when the peripheral transparent zone of the lens is fairly broad, but preference is given to this operation rather than destruction of a lens, owing to conservatism of accommodation.

Progressive Cataracts.—These begin as partial opacities, and gradually extend until they involve the whole lens. The rapidity of such progress varies greatly, as there are cases where a transparent lens becomes opaque in a few hours, whilst in others it takes years.

Senile Cataract.—This rarely occurs before fifty years of age. Two main varieties can be distinguished, sometimes occurring in the same eye—

(1) *Nuclear Cataract.*—The opacity commences centrally, as an ill-defined haze situated in the perinuclear zone.

(2) *Striated Cortical Cataract.*—Here the opacity commences peripherally, and first shows itself as opaque striæ or lines in the lens substance, which radiate from the circumference towards the centre of the lens. This variety is more frequently encountered than the other, and the opacity may begin anteriorly or posteriorly. A cataract is said to be *immature* when only part of the lens is involved, and *mature* when the whole is opaque. The latter is the most favourable time for operation, as the lens separates readily from the capsule.

After a cataract has attained maturity it may slowly degenerate (hypermature cataract), the peripheral part becoming a clear fluid, the hard nucleus sinking to the bottom, and the pupil again becoming clear. In this case a natural cure has taken place, but such is very rare, and is called a Morgagnian cataract. Most frequently a hypermature cataract consists of a milky fluid, which allows of very slight visual acuity, and greatly prejudices the good results of an operation.

Senile cataracts have always a firm hard nucleus, and when the latter is large the cataract appears of a reddish-brown colour—so-called black cataracts.

An ordinary cataract appears pearly grey by focal illumination, and black by transmitted light.

Of the cause of cataract little is known, but probably interference with the nutrition of the lens is an important factor, though how such arises is pure conjecture. The diagnosis of cataract is confined by transmitting light into the eye, which reveals the opacity as a black body in the red fundus reflex. The opacity appears to move in the reverse direction to that made by the patient's head. It is generally sector-shaped, arranged in a radiating manner, and involving any portion of the lens. If the whole lens, or that part opposite the pupillary opening, be cataractous, no fundus reflex will be found.

Symptoms.—Both eyes are usually affected, but not simultaneously. The earliest symptoms are vague, sometimes a general mistiness, varying in intensity at different times of the day, according to whether the opacity is central or peripheral. Sometimes the patient complains that the near glasses are too strong, due to an increased refractive index of the lens. The diagnosis is made by focal or transmitted light, a merely sclerosed lens imparting a dull yellowish colour to the pupil by focal illumination, but seeming to be transparent by transmitted light.

Treatment.—Early recognition of progressive cataract is important, so as to allow examination of the fundus, in order to determine whether an operation or not will be advisable later. Medical treatment, either local or general, does not influence the progress of the cataract. From time to time various medicines or sera have been zealously but rashly commended as a preventive or cure for cataract, but they hardly survive the light of publicity. So long as the cause of senile cataract be shrouded in mystery, medicinal treatment remains purely empirical. In the early stages lightly tinted neutral protectors for

outdoor use are comforting, and when the opacity is chiefly peripheral stenopaic glasses are sometimes of service. A weak concave glass often improves distant vision, and may be given for occasional use. Convex reading glasses generally have to be weakened as the case progresses. Some patients receive much benefit from amber tinted glasses, which cause in these cases an extraordinary increase in definition, a phenomenon due to pyschic causes. Blue or smoked glasses may be ordered when the opacity is central, since these cause a slight dilatation of the pupil.

Surgical treatment is undertaken when the cataract is ripe, or when immature, if the visual acuity be much diminished. Surgical measures may be of two kinds:—

(1) Removal of the whole lens, including its capsule. The advantage of this procedure is that no capsule is left to cause further interference with vision as the result of its becoming opaque, but there is a greater risk of losing some vitreous during this operation, and in this country preference is given to the following method.

(2) Removal of the lens by an incision in the capsule, leaving the latter behind. The disadvantage of this operation is that some lens fibres, especially in immature cataracts, are liable to be left behind. These later become opaque, rendering necessary a needling operation. The latter consists in introducing a needle and making an aperture in the capsule, quite a simple procedure.

The refractive correction of the aphakic eye after cataract extraction raises a few points of interest. In the emmetropic eye the static value of the lens may be regarded as equivalent to a glass lens of + 10 D, but after operations involving incision of the cornea there remains 2 D to 4 D of astigmatism against the rule, which must be added to the 10 D sph. This lens is not ordered until some six weeks or so after the operation, and during that time smoked lenses should be worn. The patient at first often experiences much disappointment at his indifferent visual acuity, even when he can read $\frac{6}{6}$ at the test types, and this is a psychical phenomenon which time gradually remedies. Another curious symptom is occasionally complained of, and comes on shortly after the operation, viz., the colouring of all objects red (erythropsia), which disappears in a few weeks.

Traumatic Cataract.—This is caused by an injury due to a sharp instrument or to violence. When the lens capsule is ruptured, allowing aqueous to permeate the lens, an opacity always develops. The capsule may be ruptured by sudden violence applied to the eye or the bony parts surrounding it, without any injury being sustained to the external coats of the eye. The rent in these cases is not in the anterior, but generally in the posterior capsule, and so the opacity develops posteriorly at first. A blow on the eye may so disturb the nutrition of the lens as to cause an opacity even where the capsule has not been torn, and the cataract then appears as a diffuse opacity. When the traumatism has also caused a tear of the sclera or cornea, the outlook is much more serious.

Diabetic Cataract.—Its clinical characteristics are similar to senile, but an examination of the urine reveals the presence of sugar.

Secondary Cataract.—When the opacity of the lens is dependent on and caused by disease of the vitreous, choroid or retina, it is called a secondary cataract. This opacity often commences at the posterior part of the lens, and the prognosis is bad, owing to the accompaniment of disease in the contiguous organs.

CHANGES OF POSITION OR DISLOCATION OF LENS.

The lens is held in position by the suspensory ligament, or zonule of Zinn, which consists of delicate fibres originating from the inner surface of the ciliary body, and passing over to become attached to the equator, partly in front and partly behind it. Changes of position of the lens are due to changes in the zonule of Zinn, which in the normal eye is tightly stretched, holding the lens so firmly that the latter remains perfectly immovable, even with the most violent motions of the head. Any tremor of the lens, or any displacement from its natural position, is due to a relaxation or destruction of the fibres of the zonule, and this may affect either a part or the entire circumference of the zonule. Dislocation of the lens may be complete (luxation) or partial (subluxation).

Luxation of the Lens.—In this condition the lens is completely displaced, either into the vitreous or into the anterior chamber. Where luxation into the vitreous has taken place the eye behaves like an aphakic one, and, if no further complications be present, the patient can see well with the correcting glass, but unfortunately complications generally ensue, such as secondary glaucoma, and the eye is often lost. The old method of cataract operation, still practised by some native Indians, consisted in depressing the lens into the vitreous, so-called "couching." A luxation into the anterior chamber is easily recognised, and the lens, when transparent, looks as if a drop of oil were lying in the anterior chamber, the upper edge appearing often of a golden hue.

Subluxation of the Lens.—The lens may be partially displaced vertically or horizontally, or it may be tilted, so that one edge of it looks somewhat forward, and the opposite one somewhat backward.

Diagnosis of Displacement.—The lens is the chief support of the iris, and when it is withdrawn from any part the latter becomes tremulous over that area on movement of the eyeball. This is best determined by directing the patient to look upwards quickly, when trembling of the iris over the subluxated area will be detected. This is characteristic of luxation. An unequal depth of the anterior chamber is also a prominent sign, and whenever this is noted there should be a suspicion of subluxation.

When the pupil is dilated, or, without this, when the displacement is large, the edge of the lens can be recognised by transmitted light as a semilunar dark shadow, and also by focal illumination, the aphakic part of the pupil appearing quite black, whilst the other part appears faintly grey.

This arises from the fact that a normal transparent lens reflects some light, so that a normal pupil is not quite black, but of a very dark grey, and this is most readily seen in large subluxations.

The aphakic area of the pupil is highly hypermetropic, and the area over which the lens extends is generally myopic, owing to the curvature of the lens being at its highest, because of rupture of the suspensory fibres.

In "luxation" the anterior chamber is deep, and the iris very tremulous, and sometimes the lens can be detected by transmitted light lying in the vitreous.

Causation.—This may be congenital, and then it affects both eyes, the lens as a rule being drawn upwards. Acquired dislocation develops as the result of trauma or spontaneously.

Traumatic Dislocations.—These are generally caused by contusion of the eyeball, and all degrees may be produced, from a slight subluxation of the lens to a complete displacement.

Spontaneous Dislocation.—This arises from a gradual softening of the zonule, which occurs as a rule in high degrees of myopia, choroiditis, and detachment of the retina.

Treatment.—Where the dislocation is so great that a part of the pupil is aphakic, we may correct the aphakic portion with a convex glass, or the other portion with a concave, according to which gives the better visual acuity. Often so much irregular astigmatism is present as to render the wearing of glasses useless.

VITREOUS HUMOR.

Chapter IX.

GENERAL DESCRIPTION.

The vitreous is a transparent, colourless, gelatinous mass which fills the posterior cavity of the eye, and occupies about four-fifths of the interior of the globe. On its anterior surface it has a depression—the fossa patellaris—in which rests the posterior surface of the lens. By its other aspects the vitreous is applied to the ciliary body, retina and optic nerve. This transparent jelly-like substance consists of a clear fluid enclosed in the meshes of an equally transparent reticulum, in which are scattered a few modified connective tissue cells known as the vitreous corpuscles. It is enclosed in a structureless envelope called the hyaloid membrane, which lies in close apposition to the pars ciliaris retinæ or retina proper. At the disc the union is firmer than elsewhere; at this spot, in fœtal life, the hyaloid branch of the retinal artery runs forwards through the vitreous to the back of the lens. Though the artery disappears before birth, yet the canal in which it ran remains, persisting as a lymph channel, and called the canal of Stilling.

In front of the ora serrata the hyaloid membrane becomes thickened and strengthened by radial fibres, and it is now called the zonule of Zinn, or suspensory ligament of the lens. The zonule has radial folds, presenting a series of alternate furrows and ridges. The ciliary processes project into and are firmly adherent to the furrows, whilst the ridges are applied to the interciliary depressions, but separated from them by a series of lymph spaces, which may be regarded as diverticula of the posterior chamber, with which they communicate. As the zonule approaches the lens it splits up into two chief layers; a thin posterior layer, which covers that portion of the hyaloid membrane lining the fossa patellaris, and a thicker anterior lamina, which blends with the lens capsule around the equator, some of the fibres running in front, and others behind the latter. The suspensory ligament retains in position the lens, whose convexity varies inversely with the degree of tension of the ligament.

The vitreous is avascular, and depends for its nutrition on the blood vessels of the uveal tract, especially those in the ciliary body. Unlike the aqueous, fresh vitreous is never generated, and a loss of vitreous occasioned by a penetrating wound is rapidly replaced by aqueous. If the amount be small, sufficient aqueous is secreted to keep the tension of the eyeball

normal, but if a large quantity of vitreous be lost, the supply of aqueous fails to meet the demand, the eye becomes soft and shrinks, and eventually sight is destroyed.

Clinical examination.—The vitreous is, in health, transparent, but diseased conditions manifest themselves as opacities. These, unless attached and fixed to the adjacent retina or ciliary body, float about in the vitreous, since its pervading reticulum or network has become destroyed. The opacities change their position with every movement of the eyeball, and they appear to the patient as one or many dark specks or filaments which float in front of the eye, moving independent of it. This is practically characteristic of vitreous opacities, for in no other media do they appear to have such independent movement.

Focal illumination.—Only an opacity stationed so far forwards as to lie immediately behind the lens can be seen by focal illumination, and it would appear as a whitish body, situated deeply in the eye.

Transmitted light.—A plane mirror and a low illumination should always be used, as a bright illumination renders the detection of fine vitreous opacities very difficult. Whilst standing at some distance from the patient the light is thrown into the eye, while the patient looks upwards, downwards, and then straight in front. The opacity will be seen as a black object moving irrespective of the eye. To examine it in greater detail the patient must be approached as for a direct ophthalmoscopic examination, using a + 6 D to + 10 D lens. Very fine vitreous opacities can only be detected by the plane mirror, and when more minute still they only produce a fogging of the fundus, but in these cases the patient complains of dimness of vision, not of specks before the eye. When floating specks are complained of, the vitreous must be most carefully examined before concluding that they are only muscæ volitantes.

Persistent Hyaloid Artery.—This artery, which runs before birth from the central retinal artery to the lens, supplying nourishment to the latter, may persist after birth. It is very rare for the persistent artery to contain any blood, though occasionally a pulsating stump may project into the vitreous. It usually appears as a greyish tag, of varying length, attached by one end to the disc or to the lens, the other lying free in the vitreous. The vision in these cases is generally subnormal.

Affections of the Vitreous.—The vitreous being avascular (without blood) and almost structureless, it cannot become inflamed in the ordinary acceptance of the term, and the changes observed are degenerative in nature, often consisting of bodies floating about, and are secondary to affections of the choroid, ciliary body or retina.

When a patient complains of motes or bodies floating in his field of vision, it has to be decided whether they are physiological (muscæ volitantes) or pathological. Muscæ volitantes occur in normal eyes, as they merely represent the ordinary cells in the vitreous, which under certain conditions become obvious to the eye in which they exist, and the patient most frequently observes them when looking up in the light or against a white

surface, especially when his lids are partially closed, as on waking in the morning. They may appear under the form of transparent filaments, or of small, clear, bead-like bodies hanging together, perhaps in rows or clusters, which move not only with the eye, but also spontaneously. They do not interfere with vision, and are most frequently complained of by myopes.

Careful examination of the vitreous, both by a plane mirror and by a + 6 D to + 10 D lens, fails to disclose to the observer any opacity, when the symptoms are caused by these physiological cells, as the latter are transparent, whilst bodies not normally present in the vitreous (pathological), can be detected by the observer, as they are opaque.

Pathological Vitreous Opacities.—These consist generally of particles of lymph or exudate deposited here in the course of inflammation of the ciliary body, choroid or retina, but the larger opacities are often due to hæmorrhages from the neighbouring vessels taking place into the vitreous. They are variable in number and shape, and are seen floating before the field of vision, shifting with each movement of the eye. The resulting disturbance of vision, if present, depends partly upon the number of opacities present, and partly upon the disease of the fundus giving rise to them. When the opacities are very minute and numerous, they can only be seen by a plane mirror and a low illumination, dilatation of the pupil being often also necessary. The opacities appear like dark dots or filaments or membranes floating about in the vitreous. Sometimes the opacities are so minute that they can no longer be perceived as distinct points, merely an obscuration of the fundus being observed; or they may appear as a faint, cloud-like opacity slowly descending in front of the pupil, and best observed after the patient has made a few rapid up and down movements of the eye, looking then straight in front. The larger opacities can be seen and examined in greater detail by using a + 6 D to + 10 D behind the ophthalmoscopic mirror.

In synchisis scintillans, particles of a silvery or golden hue are seen, falling like a shower of gold to the bottom of the eye, when the latter, after rapid movements, is held still.

Muscæ volitantes must not be confounded with scotomata, which are fixed blind spots in the field of vision, due to a loss of sensibility of a portion of the retina.

The treatment of vitreous opacities is that of the causal lesion. The patient must be discouraged from constantly looking for them, and the general health toned up.

Liquefaction of the Vitreous and Lynchisis.—This is diagnosed when opacities can be seen freely floating about in the vitreous, for the framework, in order to admit of this, must have been destroyed. This condition is always the result of disease of the adjacent membranes, and is one of the precursors of a detached retina. Later the vitreous may diminish in volume, as evidenced by a lowered tension of the eyeball.

Hæmorrhage into the Vitreous.—This may be due to rupture of the vessels of the ciliary processes, or to those of the retina or choroid. In the last case the blood must, of course, break through the retina in order to reach the vitreous. The blood is absorbed very slowly from the vitreous, but it gradually shrinks and becomes paler, appearing by transmitted light either as a dark mass or as filaments floating about. The blood ruptures the framework of the vitreous, and the latter exhibits a tendency to shrink, rendering a detachment of the retina a not unlikely consequence.

GLAUCOMA.

Chapter X.

GLAUCOMA.

This is the name given to the group of symptoms caused by an excess of intra-ocular tension. It is essentially a disease of advanced life, occurring generally in patients over fifty, a large proportion of these being hypermetropes. When glaucoma occurs independently of any other affection of the eye, it is called primary glaucoma, but when due to previous eye diseases it is known as secondary glaucoma.

A gradual increase of intra-ocular tension, if long continued, causes the weakest part of the eyeball to give way and bulge backward. The weakest part is where the optic nerve pierces the globe, as only the inner layers of the sclera (the lamina cribrosa) are present here, the outer layers being continued backwards along the optic nerve, forming one of its sheaths. The choroid ceases at the optic nerve entrance. The lamina cribrosa recedes and bulges backwards, and at the same time the optic nerve fibres, which are attached to it as they pass through, also become stretched and recede. As the result of this stretching, the nerve fibres gradually become atrophied, causing a diminution of vision, and if this has set in blindness gradually supervenes, even though the tension be reduced to normal by operation or otherwise.

An increased intra-ocular pressure causes some vascular disturbance, owing to the large veins (the venæ vorticosæ) taking a much more oblique course in their passage through the coats of the eyeball than the arteries, consequently the increased pressure compresses the veins more than the arteries, so causing a greater interference with the outflow than the inflow of blood. In a gradual increae of tension this is compensated for by a corresponding dilatation of the long anterior ciliary veins, which, like the arteries, pierce the coats, near the corneal margin, in a straight manner, and so the blood escapes more readily by these channels than by the venæ vorticosæ. (Fig. 43.)

The anterior ciliary veins are seen beneath the conjunctiva running from the corneal margin towards the fornix, and, when dilated, constitute an omen of some significance. A sudden increase of tension causes an immediate obstruction in the venæ vorticosæ, and, as the time does not allow of a compensating dilatation of the anterior ciliary veins, the blood

escapes with difficulty from the eyeball. The veins become engorged, and as a result the circulation of the lymph through the cornea is interfered with, causing the latter to have a steamy appearance, like glass which has been breathed upon.

Primary Glaucoma.—All degrees of severity are encountered, varying greatly in the rapidity of their progress. It may be so acute as to destroy vision in the course of twenty-four hours, or so chronic as to continue for months or years before such a termination occurs. It is, however, always progressive, unless checked by therapeutic or surgical measures.

For convenience of description, this condition is sub-divided into acute glaucoma and chronic glaucoma, but the latter may at any time take on an acute course. The symptoms of acute glaucoma may be divided into—

(1) Those which occur before an acute attack is actually experienced (premonitory symptoms).

(2) Those which accompany the actual attack.

Premonitory symptoms are seldom absent, though they are frequently unheeded by the patient. Slight attacks of dimness of vision, lasting only a short period, are not uncommon, the patient complaining of a fog or mist in front of the eyes, supervening often after prolonged use of them. A frequent symptom is an increasing impairment of accommodation, necessitating a lens for near work of greater strength than the age would justify, it being often necessary to increase the strength of the lens, perhaps several times, in the course of a few months, which should always remind one of the possibility of glaucoma. Artificial lights, such as gas or electric light appear at times to have a coloured ring around them.

The premonitory stage may last only a few weeks, or be protracted over months or years, but in the latter cases the eye presents those changes seen in chronic glaucoma.

The acute attack is ushered in by intense pain, sudden in onset, often radiating from the eye to the forehead, ears or teeth. Simultaneously the sight rapidly diminishes, the patient only being able to recognise hand movements The eye appears violently inflamed, both ciliary and conjunctival injection being present, the cornea cloudy and insensitive to touch. The anterior chamber is shallow, and the pupil dilated and more or less immobile. No details of the fundus can be seen, and the tension of the eye is greatly increased. The determination of the tension is performed by palpating the eyeball through the upper lid as follows : The patient, with head erect, looks well downwards, and the tips of both forefingers are placed above the tarsal cartilage in the lid, and gentle pressure is made on the eyeball by one forefinger, whilst the other appreciates the amount of displacement of fluid which the pressure occasions. Normal tension is designated T*n*, and increased tension T+, whilst diminished tension is written as T—. Immediate operation must be resorted to, or vision will be permanently lost.

Sometimes the attack is not so severe (sub-acute glaucoma), the symptoms and clinical signs being similar, but less severe. The instillation of eserine will in these cases cut short the attack.

Chronic Glaucoma, or Simple Glaucoma.—In this condition the increase of tension occurs so very gradually that no inflammatory signs are produced. The symptoms are those of the premonitory stage of acute glaucoma. Slight pain and a feeling of pressure in the eyes, aggravated by overwork, worry or a debilitated state of general health, are not unusually complained of. Although the visual acuity may be more or less normal until late in the course of the disease, yet the field of vision early becomes contracted, often commencing on the nasal side, but occasionally it partakes more of a circular contraction. Colour vision remains good until late in the disease, in contra-distinction to optic atrophy in which affection diminution of the colour field easily develops.

The patient frequently complains that he has to employ stronger and stronger glasses to see his near work; a rapid increase of presbyopia through diminution of the power of accommodation, should always excite suspicion of this affection. Later in the disease the vision becomes greatly reduced, eventually complete blindness, more or less, supervening. Glaucoma affects both eyes, one later than the other, and is met with in emmetropia and myopia, but most frequently in hypermetropia about middle age of life. It may also occur in young people.

Clinical Signs.—The eye looks quite normal externally, except that the anterior ciliary veins, which run backwards from near the corneal margin to the fornix, appear more prominent and distended. The anterior chamber is rather shallow, and the iris looks thin and attenuated. The pupil is somewhat dilated—a rather unusual occurrence in elderly people—and only reacts sluggishly to light. The media are clear, and the tension is more or less normal. The above signs, by no means definite, may be seen in normal eyes, but it is the ophthalmoscopic appearance of the disc which decides whether the case be glaucomatous or not.

Ophthalmoscopic Examination.—In the early stage the margins of the disc are regular and well defined, but later choroidal changes around the disc are found, the latter being surrounded by a yellowish or whitish areola, the bluish-white lustre of the disc contrasting with the white atrophic area, and preventing the latter from being mistaken for the disc proper. The excavation (cupping) is the most characteristic ophthalmoscopic sign, and this always *extends to the margin* of the disc, though at first the whole of the disc may not be involved, but only a part. In that part, however, its cupping extends to the edge of the disc, whilst a physiological cupping ceases before it reaches the margin. Later the whole disc becomes deeply cupped, and on the floor of the excavation may be seen the grey dots of the lamina cribrosa. The cupping is recognised by parallactic displacement, or, in the direct method, by the fact that when the edge of the disc is in focus, the disc itself is only indistinctly seen, owing to it being in a more posterior plane, the substitution of a concave lens being necessary in order to see the papilla clearly (1 D = 0.3 mm. in depth. The blood vessels do not emerge at the centre of the papilla, but close to its inner margin. In deep

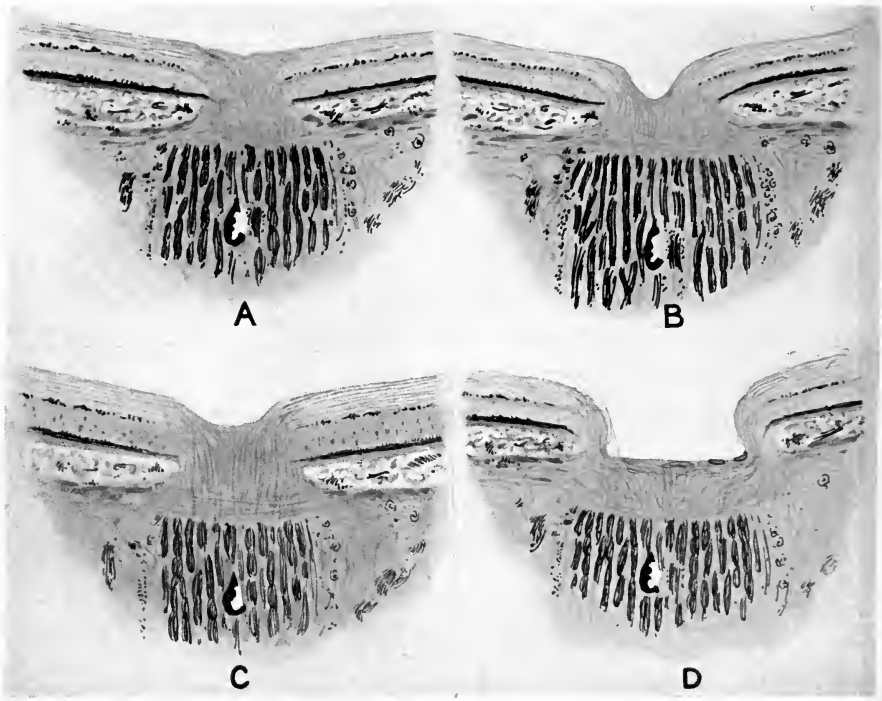


PLATE IV.

A LONGITUDINAL SECTION OF NORMAL PAPILLA Stained with Weigert's stain, which colours medullary sheath and blood black.

Note.—Cessation of medullary sheath at lamina cribrosa, and contraction of nerve as it passes, also interruption of choroid at nerve entrance. No excavation, and central nerve fibres do not pass over to periphery until their exit.

B—Ditto, with large central excavation owing to central fibres passing over to periphery. Lamina cribrosa not displaced.

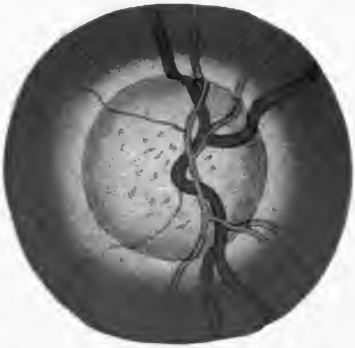
C.—PATHOLOGICAL CUPPING (Optic atrophy).

Note.—Shallow cupping involves the whole of the disc, lamina cribrosa being normally situated.

D.—PATHOLOGICAL CUPPING (Glaucoma).

Note.—Deep cupping involving the whole disc, lamina cribrosa being displaced backwards.

A



B

C

PLATE V.

A.—NORMAL PAPILLA SEEN OPHTHALMOSCOPICALLY.

Note.—Central physiological cupping paler than rest of disc, with stippling of lamina cribrosa. The black ring is due to choroid, but it is rarely so distinct as this.

B.—PAPILLA IN GLAUCOMA.

Note.—Whitish halo around margin of disc, colour of which is bluish white. Cupping of vessels extends to margin of disc, arteries being rather small and veins dilated.

C.—PAPILLA IN OPTIC ATROPHY.

Note.—Edge of disc well defined, vessels small, disc white, and cupping extends to edge of papilla.

excavations the vessels cannot be seen ascending the sides of the cup, as they are hidden from view by the overhanging margin, so that those visible on the floor are lost to view as they ascend the side, and reappear, changed in number and position, as they bend round the margin of the disc to gain the retina.

When associated with staphyloma posticum (myopic crescent) the glaucomatous cup is larger in diameter than usual, appearing oval instead of round, and the sides of the cup are more sloping (not so steep) than in the ordinary glaucomatous cup. The lumen of the arteries is smaller than normal, whilst pulsation may be observed in them, or, if not, slight pressure made by the finger on the globe during ophthalmoscopic examination will cause pulsation to appear. Retinal arterial pulsation is very significant of glaucoma. The retinal veins are more dilated than usual, and pulsation in them is frequently observed, but this also may occur in healthy eyes.

The colour of the disc in glaucoma varies from a bluish white, in the earlier stages, to a greenish white later, and the floor of the cup presents the grey dots of the lamina cribrosa.

Three kinds of excavation of the disc are differentiated, and their distinctive signs are as follows. (Plates IV. and V.):—

Physiological Cupping.	*Glaucomatous Cupping.*	*Atrophic Cupping.* *(Primary Atrophy of Nerve.)*
Edge of disc normal.	In later stages a ring of choroidal atrophy is seen around the disc.	Edges well defined.
Blood Vessels, of usual calibre, are seen ascending on the inner wall of the cup. No arterial pulsation is observed but venous pulsation may be present.	Arteries are smaller but the veins are dilated, and the vessels seem to arise from the nasal margin of the disc. Arterial pulsation is commonly observed, as also is venous.	Blood vessels small and contracted
The excavation may be deep or shallow and include a small or the larger part of the disc, but it does not extend to the margins of the papilla.	The excavation is deep, and at first may not include the whole of the disc, but it always extends to the margin of the papilla.	Excavation is shallow—saucer shaped—and extends to the margin of the disc.
The cupped area is whiter than the rest of the disc, the latter appearing of a reddish color by contrast. At the bottom of the cup is seen the greyish stippling of the lamina cribrosa.	The whole disc appears of a bluish white colour, though, in the later stages it seems of a greenish hue. The stippling of the lamina cribrosa is well seen.	The disc appears quite white, and the lamina cribrosa is clearly discernible.
The lamina cribrosa is in its normal position.	The lamina cribrosa is pushed back, lying more posteriorly than usual.	The lamina cribrosa is in its normal position.

Diagnosis.—Though the symptoms in middle-aged people of transient obscurations, or coloured rings around lights, or an increasing abnormal impairment of accommodation, or ocular headaches associated with bilious attacks, are suggestive of glaucoma, especially when the anterior ciliary veins are dilated, and the anterior chamber is shallow, yet its absolute diagnosis depends upon the presence of cupping. Where the latter affords no certain clue, the fields of vision for form or colour should be taken when the above symptoms are present. In glaucoma the contraction of the field

generally commences in the nasal half, and the colour field presents a restriction corresponding with that of the form fields, whilst in optic atrophy the peripheral colour vision, especially for red and green, is markedly deficient. In glaucoma the light minimum is said to be deficient, whilst the light difference is not far from normal, but practically this examination is so difficult to conduct as to render the results unconvincing.

Cause of Glaucoma.—In order to understand the nature of glaucoma, it is necessary to be conversant with the anatomy of the anterior chamber, and the function of the aqueous humor, as the rise in tension in the eyeball is chiefly due to either increased production of aqueous or interference with its exit. At the corneo-scleral margin, the inner lamellæ of the cornea break up into bundles of fibres, which chiefly afford attachment to the ciliary muscle, though a few are continued around the angle of the anterior chamber into the substance of the iris. These radiating and anastomosing bundles of elastic fibres are called the ligamentum pectinatum, and they are covered with endothelial cells continuous with those covering the posterior surface of the cornea. These cells only form a lining to the bundles, and do not stretch across the intervals between them, the aqueous freely communicating with the spaces between the bundles of the ligamentum pectinatum. These spaces are called the spaces of Fontana, and they communicate with another large space situated a little in front of them, close to the corneo-sclerotic junction, and called the canal of Schlemm, or sinus circularis iridis. This canal of Schlemm communicates on the one hand with the aqueous chamber through the spaces of Fontana, and on the other hand with the anterior ciliary veins in its immediate vicinity.

The aqueous humor supplies nutrition to the adjacent parts, and forms a fluid bed to allow for the free movement of the iris. It is largely secreted by the ciliary processes, and flows firstly into the posterior chamber, passing through the pupil into the anterior, and escaping from the anterior chamber into the anterior ciliary veins through the spaces of Fontana and the canal of Schlemm.

There are other lymph paths within the eye by which its nutrient fluid can escape, as the perichoroidal space between the choroid and sclera, and the canal of Stilling in the vitreous chamber, both of which empty posteriorly into the lymph channel of the optic nerve sheaths, but the anterior lymph circulation through the anterior chamber is by far the most important, and it is to obstruction of these paths that glaucoma is due.

The intra-ocular pressure is largely a matter of balance between the inflow and the outflow of ocular contents, as the internal capacity of the envelopes remains more or less the same. Though the intra-ocular pressure would be raised by an increased inflow unless there was a corresponding increased outflow, yet it is most probable that the cause of ordinary glaucoma is due simply to an interference with the outflow.

Priestley Smith has shown that the circumlental space diminishes as age advances, owing to the continuous growth and enlargement of the lens, and when the ciliary body is also large, as in hypermetropes, this space is still

further encroached upon. As a result the iris is pushed forwards, especially towards the ciliary margin, where sometimes at the periphery it is in contact with the posterior surface of the cornea, thus closing the source of exit for the aqueous humor, and, as a consequence, increased tension in the eyeball results.

Henderson, of Nottingham, in a recent book, combats the above volumetric theory of glaucoma. His conception of the mechanism of intra-ocular pressure is based upon Leonard Hill's discovery that the pressure within the skull is equal to, and varies directly with, the pressure of the blood in the intra-cranial veins, and that the intra-ocular pressure is equal to the intra-cranial, so that they rise and fall together. This Hill demonstrated experimentally. Intra-ocular pressure, according to this theory, is not dependent upon the relation of inflow of contents and outflow, but is vascular in origin, the pressure being equal to the lowest venous pressure, viz., that in Schlemm's canal, and varying directly with it. The free contact between aqueous and veins causes the intra-ocular pressure to be maintained at that of the blood in Schlemm's canal. In glaucoma the contact is diminished, and the intra-ocular fluids, being contained in an unyielding capsule, act as a rigid volume, which compels the circulation to run in rigid lines. Now, in a rigid system the outflow pressure is always higher than in a similar system of elastic tubes, and in glaucoma the circulatory pressure is that in a rigid system, and therefore the intra-ocular pressure is maintained at a corresponding high level. Henderson maintains that the aqueous is not secreted by the so-called ciliary glands, but by cells lining the apices of the ciliary processes, and that it passes into the anterior ciliary veins by an active process of resorption, neither the inflow nor outflow of aqueous being a passive filtration, and he also asserts that the cornea is nourished by aqueous diffusing through the ligamentum pectinatum.

Treatment.—In acute glaucoma the operation of iridectomy is urgently indicated, and, if performed early, a good result is frequently obtained. In simple glaucoma rest to the eyes and abstention from near work is imperative. Myotics, as eserine, are instilled into the eye, the resulting contraction of the pupil tending to keep the angle of the chamber more patent, though if such contraction is not obtainable, operative measures are suggested, but these do not give such good results as in the acute attack. A large portion of the iris may be removed (iridectomy), or an attempt may be made to create a scar by excising a portion of the sclera, which will admit of the filtration of the aqueous into the subconjunctival tissue.

Secondary Glaucoma.—By this is understood an increase of tension appearing in the course of other diseases of the eye, and as a consequence of them. The clinical picture is similar to that of primary glaucoma, modified by the additional signs of the causal disease. It is a common complication of irido-cyclitis, due either to the pupillary border of the iris being bound down to the anterior surface of the lens (seclusio pupillæ), thus preventing the flow of aqueous from the posterior to the anterior chamber, or to the more viscid nature of the aqueous humor resulting from cyclitis, which hinders its percolation through the spaces of Fontana.

Dislocation, partial or complete, occasionally causes acute glaucoma, as also do retinal or choroidal hæmorrhages and intra-ocular tumors.

In all cases of glaucoma, especially when occurring in younger people, present or previous eye disease must be carefully excluded.

Buphthalmus (ox eye).—This is a disease of childhood, in which the eye becomes of an unusual size. It arises from obliteration of the angle of the anterior chamber, and as a consequence the intra-ocular pressure rises, causing a gradual expansion of all the coats of the eyeball, the latter not having the resistive powers which they possess later in life.

Diminution of the intra-ocular pressure is a sign that the contents of the eyeball have diminished in volume, and is generally the result of previous disease. It is commonly associated with detachment of the retina.

THE CHOROID.

Chapter XI.

ANATOMY.

The choroid, ciliary body and iris together form the uveal tract, whose function, owing to the numerous blood vessels it contains, is chiefly concerned with supplying nutrition to the internal parts of the eye. The choroid forms the posterior two-thirds of the uveal tract. It is interposed between the sclerotic and retina, and commences anteriorly at the ora serrata—where the ciliary body begins. It forms a continuous deeply-pigmented coat, except at the optic nerve entrance, where it is absent in order to allow the entrance of the nerve into the globe. Thicker behind than in front, the outer surface is flocculent, and connected to the sclera by a loose areolar tissue—the lamina fusca—which serves to transmit the ciliary nerves and the long ciliary arteries as they pass to the ciliary body.

The choroid consists of blood vessels and branched pigment cells imbedded in a loose connective tissue, and is described as presenting from without inwards three layers—

(1) Lamina suprachoroidea, or fusca—described above.

(2) The choroid proper.

(3) A thin transparent membrane called the membrane of Bruch. This layer lies next to the retinal pigment layer, from which it is produced, and so it is really a part of the retina.

The choroid proper consists chiefly of blood vessels and pigment cells, the former being so arranged that the smallest—the choroid capillaries—lie most internal and next to Bruch's membrane, and the largest are placed most external, lying adjacent to the lamina fusca. They collect the blood into four or five main trunks—the venæ vorticosæ—which pass out of the sclerotic near the equator of the globe, and empty the blood into the ophthalmic vein. The arteries are derived from the short posterior ciliary, which pierce the sclera around the optic nerve entrance.

The pigment of the choroid is most dense in its external layers, gradually diminishing towards the retina, the choroidal capillaries and Bruch's membrane being entirely devoid of it. It is situated between the blood vessels in variously shaped cells arranged irregularly. The choroid is not well supplied with nerves, so that inflammation of the structure is not accompanied by pain.

The retinal pigment layer and the outer retinal layers are dependent upon the choroidal capillaries for their nourishment, the retinal artery only supplying the innermost layers of the retina.

The choroidal vessels can be readily distinguished ophthalmoscopically from the retinal as below:—

Choroidal.	*Retinal.*
These are flat and ribbon shaped, and branch in an irregular manner, the branches freely anastomosing with each other. No light reflex is present.	These are rounder, and branch in an arborescent manner, but the branches do not anastomose with one another. A light reflex is present, running along the centre of the vessel.

Congenital Abnormalities of the Choroid.

Coloboma of the Choroid consists in an absence of the choroid, and is most commonly situated in the midline of the floor of the fundus, running backwards from near the optic nerve entrance to the ora serrata. It appears ophthalmoscopically as a sharply defined white patch, its edges commonly being bordered with pigment; the retinal blood vessels often run around the edge instead of pursuing their ordinary course, which would be across the coloboma, this distinguishing it from an old choroiditis, in which the retinal vessels run in the normal way. The coloboma varies greatly in size, and is sometimes associated with a coloboma of the iris. Most frequently the coloboma is limited to a small patch below the disc, called Fuch's coloboma, which has the ophthalmoscopic appearance of a myopic crescent, except that it is situated below the disc instead of external to it, and in this condition a diminished visual acuity is always present.

Albinism.—In this abnormality there is a lack of pigment, not only in the eye, but also in the rest of the body. The child has very flaxen hair, with white eyebrows and lashes, and vision is poor, nystagmus (slight rapid movements of the eyeball) often being present when any attempts at fixation are made. The iris is light grey, and appears reddish by transmitted light. Owing to the small amount of pigment present in the retinal pigment layer and in the choroid, the vessels of the latter are seen ophthalmoscopically coursing and interlacing over the white background of the sclera.

Albinism is congenital and inherited, and all degrees exist, from a complete absence of pigment to only a slight diminution.

PATHOLOGY.

Inflammation of the Choroid—Choroiditis.—We divide this into two subdivisions, according to whether the inflammation leads to the formation of pus or matter (suppurative choroiditis) or results only in the escape of lymph (exudate) from the vessels (non-suppurative or exudative choroiditis). The former condition is rarely met with, except when caused by a penetrating wound of the eye, the resulting inflammation involving all the structures, and as a consequence complete destruction of the globe not uncommonly results.

Non-suppurative or Exudative Choroiditis.—When choroiditis is spoken of, this is the form which is alluded to. It may be circumscribed in extent or diffuse, and even spread so far forwards as to involve the ciliary body and iris (choroido-iritis), or, again, it may commence in the latter and spread backwards to involve the choroid. This is not surprising, as really the iris, ciliary body and choroid form one continuous whole.

The retina is also frequently involved (retino-choroiditis), for it principally receives its blood supply from the choroid, and so any affection of the latter must disturb its nutrition and cause changes in it. The eye looks normal, and the disease manifests itself to the patient only through some disturbance in sight, which varies in degree according to the part of the fundus affected, and is recognised only by ophthalmoscopic examination, except when the iris and ciliary body are also affected. In the latter case the objective signs of iridocyclitis will be present, as posterior synechiæ, keratitis punctata (K.P.), and fine vitreous opacities.

The ophthalmoscopic appearances differ in a recent choroiditis from those in a chronic case :—

Recent Choroiditis.	*Old Choroiditis.*
The fundus is a little indistinct owing to minute vitreous opacities.	Fundus generally clearly seen.
Retinal blood vessels are more or less engorged, but they pass in front of the affected area, in contradistinction to retinitis.	Retinal blood vessels normal, passing in front of the choroidal patch.
The choroiditic patch is of a greyish white colour, and slightly raised above the level of the rest of the fundus. Its margins are ill defined from the surrounding retina, and no choroidal vessels are seen.	The choroidal patch is white, with perhaps pigmentary deposits scattered irregularly through it, or more especially around its border, which is clearly cut and well defined from the rest of the retina. Remains of choroidal vessels can be frequently seen coursing through the white patch, and the latter lies generally slightly below the level of the rest of the fundus.
The greyish white patch is due to an infiltration of the choroid with exudate, which hides the red of the choroidal vessels, and the overlying retina is clouded and grey, covering the subjacent choroidal patch as with a faint veil.	The white patch is due partly to scar tissue, as the choroid has been destroyed by the inflammation, and partly to the sclera showing through.

Choroiditis is very chronic in its course, taking many weeks for the patches of exudation to be converted into scar tissue, but in slight cases the exudate occasionally becomes absorbed by the surrounding tissue, instead of destroying the latter, the choroid then returning to the normal again. Choroiditis is a very common disease, and is observed at all ages. It is often met with in general diseases, such as syphilis, anæmia, etc., but it is also frequently caused by small collections of pus in different parts of the body, such as the nose, teeth, breast, etc., the poison of which enters the blood stream and irritates the choroid.

Myopia is frequently complicated with choroidal changes; in fact, it is rare to find a normal choroid in the higher degrees of myopia. These

choroidal changes are atrophic in nature rather than inflammatory, and are due to the stretching which the choroid must necessarily undergo when the entire posterior segment of the sclera bulges backwards (posterior staphyloma), as is the case in high myopia.

The treatment of choroiditis consists chiefly in the eradication of the cause. In a recent attack the eyes must be rested and protected from the light by dark glasses. Hot fomentations and leeches applied to the back of the ear relieve the engorgement of the blood vessels, and tend to promote a more rapid healing.

Syphilitic Choroiditis.—Though syphilis may cause many different types of choroiditis, yet the following ophthalmoscopic changes are characteristic of it. Appearing at first around the periphery of the fundus are white circular spots of different sizes, having a punched-out appearance. Their margins are lined with pigment, and the more recent may have a yellowish-red appearance, differing little from the rest of the fundus, and very likely to be overlooked unless the fundus is carefully examined. As time advances they gradually become whiter. Occasionally, instead of white patches with pigmented borders, there may appear spots of pigment surrounded by a pale margin, the retinal vessels, of course, running in front of these areas. Also the pigmented epithelium layer lessens all over the fundus, exposing to view the vascular network of the choroid, with here and there small islands of pigment between them. The changes are most marked in the early stages in the periphery of the retina, but later all the fundus is attacked. This condition is commonly called disseminated choroiditis (Plate VI.) Another common syphilitic affection is retino-choroiditis, in which the retina appears cloudy, owing to fine dust-like opacities in the vitreous, and circumscribed ill-defined exudates are indistinctly seen in the retina and choroid. Later a picture like that of retinitis pigmentosa is presented.

Senile Choroiditis.—In old people a chronic choroiditis, often occurring in both eyes, and limited to the macular region, is not uncommon. The choroid in the macula is dotted over with minute black or yellowish white specks, looking as if it had been dusted with a mixture of pepper and salt. This condition must not be confounded with Tay's choroiditis.

Myopic Choroiditis.—The choroidal changes in myopia partake more of the nature of a thinning (atrophy) rather than an inflammation of the choroid, owing to the enlargement of the posterior third of the eyeball.

Posterior Staphyloma or Myopic Crescent.—This condition is recognised by the ophthalmoscope as a white crescent at the outer side of the papilla. The posterior bulging of the eyeball causes atrophy of the choroid at this place, and it sometimes extends all around the disc. The crescent at first merely appears of a lighter colour, later becoming white, with pigment around its border. This lies at a slightly lower level than the contiguous parts of the fundus, as will be manifested by parallactic displacement. Occasionally two or three contrasting zones exist in the staphyloma, lying at slightly different levels, and differing from each other in their pigmentation, the recent zone being less pale in colour and at a slightly higher level

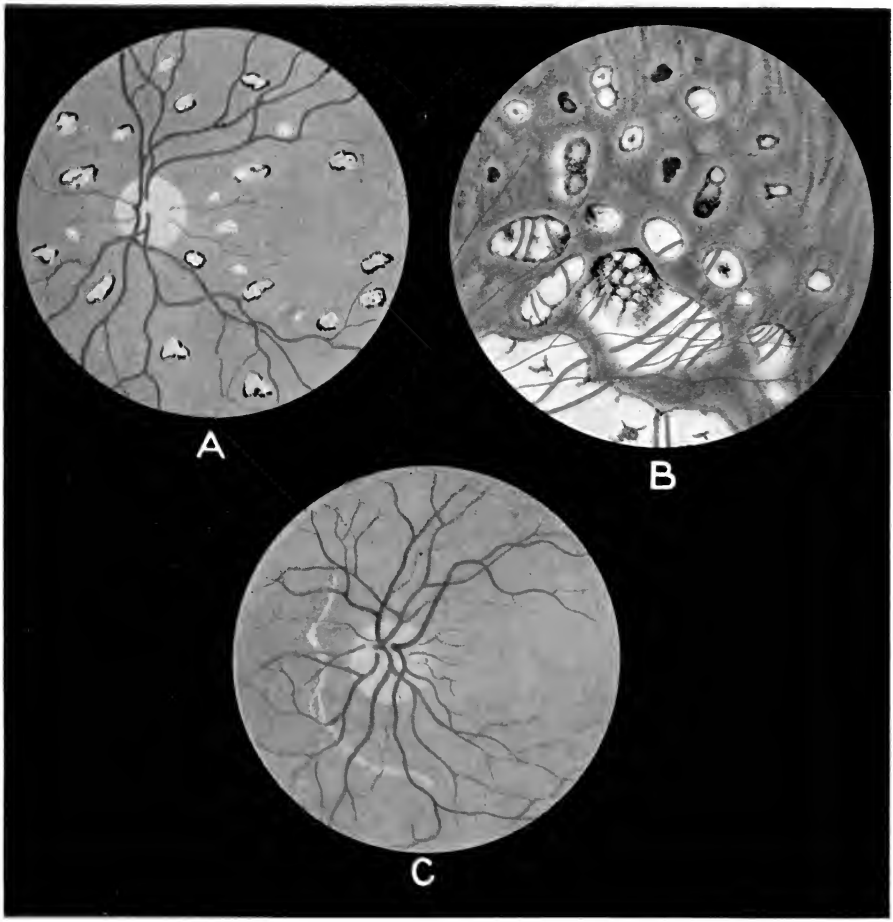


PLATE VI.

A. DISSEMINATED CHOROIDITIS.

Note. More or less circular whitish areas with pigmented borders. Atrophy of retinal pigment layer has not taken place yet, so that choroidal vessels cannot be seen.

B. Ditto (more advanced stage, a portion only of fundus being shown).

Note. Well-defined edges and varying pigmentation of affected areas. Choroidal vessels crossing light patches. They are broader and flatter than retinal vessels which course over them.

C. RUPTURE OF CHOROID.

Note. The rent is concentric with disc, with retinal vessels in front of it. Its shape is characteristic, with buff colored edge.

For use of several of the Fundus plates we are indebted to the proprietors of "Haab's Atlas of Ophthalmoscopy."

than the others, thus showing that the formation and enlargement of the staphyloma have taken place at different periods. If the crescent is indistinctly defined from the adjacent healthy choroid, it presumes an increase in the myopia, and the case should be seen at short intervals, and near work more or less suspended, whilst if the border is clearly defined and perhaps lined with pigment, the inference is that the myopia is not progressing.

Macular Changes in Myopia.—This should always be carefully looked for, as the region of the yellow spot is very liable to be involved in the higher degrees of myopia. Slightly lighter-coloured spots are often the only signs at first observed, and these gradually become paler, and tend to coalesce, forming later on rather large whitish areas, with a varying amount of pigmentation in them. Hæmorrhages are not uncommon in the macular area, owing to the rupture of a blood vessel in the stretched choroid, and commonly, in high degrees of myopia, a coal-black round spot appears in the macula, which may become as large as the size of the disc.

Detachment of the retina, and vitreous opacities arising from the myopic condition, are dealt with in Chapters IX. and XII.

Degeneration of the Choroid.—In old people, especially if their eyes have been diseased, small white slightly-raised bodies, about half the size of a pin-head, are seen scattered singly or grouped in little masses, especially about the macula lutea, or between it and the disc. Vision may or may not be affected. It is frequently called Tay's choroiditis, and is due to degenerative changes in Bruch's membrane.

Rupture of the Choroid.—This expression is used to denote a tear in the choroid coat when accompanied by no changes in the sclera, and is not applied to perforating wounds involving the choroid. It is caused by a severe blow on the eye, and the rupture invariably occurs at or near the posterior pole, as the globe is less supported here. Immediately after the injury the blood escapes into the vitreous, and prevents a clear view of the fundus, but when this has cleared up the rent in the choroid is seen as a sharply-defined jagged streak, over which the choroidal vessels cross. This is due to the edges of the laceration separating from each other, allowing the white sclera to be seen between them. (Plate VI.) One or more of these linear splits may be observed, but they all lie in the neighbourhood of the posterior pole, usually on the outer side of the disc, and are more or less vertical in direction, presenting a slight concavity towards the papilla. Treatment chiefly consists in bodily as well as ocular rest.

Detachment of Choroid.—This very rarely occurs. It appears ophthalmoscopically like a detached retina, except that the choroidal vessels would also be distinctly seen.

Tumors of the Choroid.—These are generally malignant, and they at first appear ophthalmoscopically as a detachment of the retina, which differs from the ordinary kind by the fact that the upper part of it is solid, and appears fairly well defined, but if any new blood vessels or hæmorrhages are present over this area, no doubt can exist as to the nature of the affection.

The lower part of the detachment is often only an ordinary serous one, and arises owing to the disturbance of the choroidal circulation by the growth.

All detachments occurring in normal eyes without any history of injury must be viewed with grave suspicion, and in doubtful cases removal of the eye is indicated, as it is wiser to sacrifice that rather than incur any risk to life.

There is no difficulty in recognising this affection in its late stages, as the growth invades the vitreous and the other structures of the eyeball.

THE RETINA.

Chapter XII.

ANATOMY.

The retina is a delicate membrane containing the terminal end organs of the fibres of the optic nerve, supported by a connecting framework. It lies between the choroid and the hyaline membrane of the vitreous humor, and extends from the optic disc to the ciliary processes, presenting at the latter a finely indented border, the ora serrata. Here most of the individual retinal elements cease, but they are continued over the ciliary body as a layer of columnar cells, forming a lining to the layer called the pigment epithelium of the retina, which is also continued on to the ciliary body and iris, constituting those previously described layers, the pars ciliaris retinæ and the pars iridica retinæ. The retina diminishes in thickness from 0.4mm. around the optic nerve entrance, to 0.2mm. anteriorly. It is everywhere easily detached from the subjacent choroid, except at the ora serrata. In the living eye the retina is perfectly transparent, and of a purplish-red colour, the latter depending upon the visual purple present in the rods, but after death it rapidly becomes opaque, appearing as a frail white membrane. Pathological changes in the living retina manifest themselves as opacities, and are easily recognised as such by the ophthalmoscope.

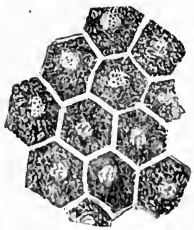


Fig. 56.

Pigmented epithelium of human retina (viewed from the surface).

Viewed from the front, the retina presents at its posterior pole a small yellowish spot, the macula lutea, which is somewhat oval in shape, its long axis being horizontal, and measuring from 2 to 3 mm. In its centre is found a small depression, called the fovea centralis. About 3 mm. to the

nasal side of the macula, and about 1 mm. below its level, is a whitish circular disc of about 1.5 mm. diameter, the optic disc, which corresponds with the entrance of the optic nerve. The circumference of the optic disc is generally slightly raised, whilst its central portion is depressed, forming the optic cup.

The retina consists of two parts, having different functions. These are: (*a*) The nervous part; (*b*) the sustentacular or sustaining part, which provides a framework for the nervous elements.

The nervous part, or retina proper, consists of many layers, arranged as follows from choroid to vitreous:—(1) The pigmentary layer, (2) the rods and cones, (3) the outer granular layer, (4) the outer molecular layer, (5) the inner granular layer, (6) the inner molecular layer, (7) the ganglionic layer, (8) the nerve fibre layer.

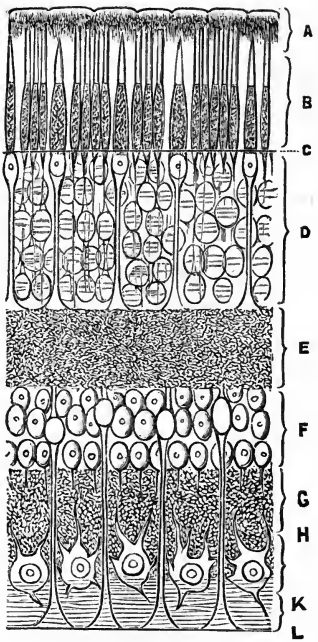


Fig. 57.

Diagrammatic section of the human retina.

A The pigment layer. *B* Rods and cones. *C* External limiting membrane. *D* Outer granular layer. *E* Outer molecular layer. *F* Inner granular layer. *G* Inner molecular layer. *H* Ganglionic layer. *K* Nerve fibre layer. *L* Internal limiting membrane.

(1) *The pigmentary layer* bounds the retina externally, and is developed from the outer lamina of the optic vesicle. It consists of a single layer of six-sided (hexagonal) cells, whose outer part contains a nucleus and is

devoid of pigment. (Fig. 56.) The inner part is loaded with pigment granules, and it has a narrow, long tail extending into the region of the rods and cones. Immediately external to this pigmentary layer, separating it from the choroid, is a thin homogeneous membrane—the membrane of Bruch—which is a product of the pigment cells.

(2) *The layer of rods and cones.*—These constitute the most important layer, and they are placed at right angles to the plane of the retina. The rods extend externally as far as the pigment layer, and are cylindrical in form. The cones are shorter, thicker, and swollen at their inner extremity, whilst externally they end in a tapering filament, which does not quite reach the pigment epithelium. Both rods and cones are divided into two segments, an outer and inner. The outer rod segments are cylindrical in shape, and are unaffected by stains, but they have a remarkable tendency to split up into highly refractile superimposed discs, like a pile of coins. They are of a purple colour, owing to the visual purple or rhodopsin which they contain. The outer cone segments are similar to the outer rod segments, except that they contain no visual purple, and are conical in shape. The inner segments of both rods and cones are singly refractile, stain readily with carmine, and are larger in diameter than the outer segments, but they taper towards the end.

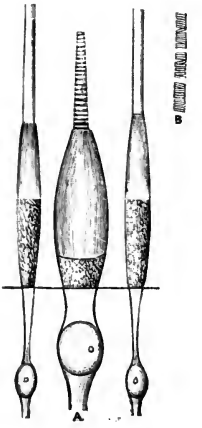


Fig. 58.

A A cone and two rods from the human retina. *B* Outer part of rod separated into discs.

(3) *The outer granular layer (outer nuclear).*—On entering this layer, each rod almost immediately becomes a fine tapering fibre extending down for a variable distance, expanding to enclose an oval transversely striated nucleus, and then continuing on as a fine nodulated fibre to enter the next layer. Each cone enters as a thin filament, and immediately surrounds a nucleus, continuing on into the next layer as a nervous fibre, but slightly broader than that of the rod.

(4) *The outer molecular layer* contains the terminations of the rod and cone fibres, the former ending in small knob-like expansions, and the latter in broad bases or feet. Both these endings are surrounded by a network of fibrils, which are connected with the cells in the next layer.

(5) *The inner granular layer (inner nuclear)* contains two varieties of large nerve cells. One—the bipolar cell—has two tail-like processes, one passing up to the preceding layer, and the other in the opposite direction. Each ascending process ends either around the button-like process of a rod in the preceding layer (rod bipolar), or around the foot-like process of a cone (cone bipolar). There are also many horizontal cells in this layer.

(6) *The inner molecular layer* consists chiefly of the descending processes of the bipolar cell of the previous layer, and ascending branches of the cells in the following layer, each branching up into numerous ramifications.

(7) *The ganglionic or nerve cell layer* consists of a single layer of large oval-shaped cells, which, on their outer side, give off numerous branches running into the inner molecular layer, and on their inner side give off a single fibre, which chiefly forms the next layer.

(8) *The layer of nerve fibres or stratum opticum* consists chiefly of the nerve fibres given off by the nerve cells in the preceding layer, and which collectively form the optic nerve at the disc, conducting the retinal sensations to the brain. There are also a few fibres carrying impressions from the brain, and ending in the inner nuclear layers.

The sustentacular fibres support the nervous structures, and extend from within outwards through the thickness of the retina as far as the bases of the rods and cones. These fibres begin on the inner surface of the nerve fibre layer in the form of expanded bases, by the apposition of which a delicate membrane, the membrana limitans interna, is formed. The fibres pass out to the outer nuclear layer, where they break up into a network of fibrils surrounding the rods and cones, forming the membrana limitans externa.

This complicated structure of the retina is practically a series of nerve fibres, with nerve cells interpolated between them, and arises owing to the visual impressions being formed in the cells in the outer portion of the retina (rods and cones). The various nerve fibres conduct these impressions *via* the optic nerve to the brain.

The yellow colour of the macula is due to the presence of pigment in the inner layers of the retina. At the circumference of the macula the nerve fibre layer is greatly thinned, and the rods are few in number, but the ganglionic layer is much thickened, possessing from seven to nine strata instead of only one, as in other parts of the retina. At the fovea centralis the retina is thinner still, as here its nerve fibre and ganglionic layer are absent. There are no rods, and the cones are crowded together, but the pigment layer is thicker.

At the ora serrata the retinal nervous elements suddenly cease, the layer of rods and cones first failing. In front of the ora serrata the retina is prolonged over the ciliary processes in the form of two layers of cells: (*a*) an inner layer of columnar cells, representing all the retinal layers except the pigmentary, (*b*) an outer layer, consisting of the retinal pigment layer. The two together form the pars ciliaris retinæ, and these two same layers are prolonged over the back of the iris, where both are pigmented, forming the pars iridica retinæ.

Vessels of the Retina.—The retina is supplied by the arteria centralis retinæ, a branch of the ophthalmic artery, which pierces the sheath of the optic nerve about ¾ in. behind the eyeball, and makes its appearance in the centre of the optic disc. Here it divides into an upper and a lower branch, and each of these again bifurcates into an internal or nasal, and an external or temporal branch. The resulting four branches ramify towards the periphery of the retina, and are named the superior and inferior temporal, and the superior and inferior nasal arteries. The temporal arteries pass outwards above and below the macula, to which they supply branches, but these do not extend so far as the fovea centralis, which is devoid of blood vessels.

The larger blood vessels run in the nerve fibre layer near the limitans membrana internans, and they send branches which penetrate as deep as the inner granular layer, from which the veins arise. The latter accompany the arteries, being generally placed to their outer side. The retinal arteries are terminal, as no anastomosis or connection takes place between the various branches, this having an important bearing in cases of arterial obstruction, for death of that part of the retina supplied by the obstructed artery takes place, as its blood supply is totally cut off. The retinal arteries only nourish the inner layers of the retina, whilst the outer derive their nourishment from the choroid, the macular area being chiefly supplied by the choroid capillaries.

PHYSIOLOGY.

When light falls upon the retina, certain changes of a mechanical, chemical and electrical nature are produced. The pigment of the pigment epithelium cell, together with its fine process, moves forward to embrace the outer segment of the rods and cones, the pigment cells becoming acid in reaction, accompanied by bleaching of the visual purple of the rods. Besides these physical and chemical actions there are also definite electrical changes, and though it is admitted that the above changes take place under the influence of light, yet their relative significance is much disputed. Purkinje's figures and Mariotte's experiment with the cross or dot prove that the images are formed behind the nerve fibre layer, and probably in the rods and cones. As only the latter are present in the fovea centralis, their appreciation of form is much greater than that of the rods. In order that two points may give rise to separate visual impressions, their images must be at least 0.003 mm. apart, for since this is approximately the diameter of the macular cones, images which are nearer together would only stimulate one cone, and so give rise to a single visual impression.

Both rods and cones are capable of producing the sensation of light, but the response to the sensation of colour probably lies only in the cones. The nature of the transformation undergone by the ethereal vibrations in the rods and cones is still hotly disputed, some favouring an electrical change, some a photo-mechanical, and others a photo-chemical, but the resulting nerve stimuli are conducted by the nerve fibres to the brain, where their interpretation takes place. Each rod and cone receives light from one point in the visual field, and from one only, and this correspondence between the element excited and the position of the point from which the light proceeds enables us to judge of the relative position in space of these points. Our judgment, however, receives some unconscious support from other senses, and many sensations which seem to be simply visual—such as those of size, distance and solidity—are in reality complex, and depend to a certain extent on the teaching of experience, on muscular sense, which tells us the position our eyes are in, on the amount of convergence and accommodation used, and on a comparison with well-known objects. For distinct vision the image must fall on the fovea centralis, and this is called central or direct vision, whilst when it falls upon any other part of the retina it is called indirect or peripheral vision, but in low degrees of illumination the fovea is less sensitive than the surrounding parts.

In order that the two retinal images of an object may give rise to a single visual impression, it is necessary that the images should fall on corresponding retinal areas, and the upper halves of both retinæ correspond, as also do the lower, but the nasal side of one corresponds with the temporal of the other, and *vice versa*. Our visual sensations are of three different kinds, inasmuch as in looking at objects we take cognisance of their form, colour and brightness. The faculty by which we recognise the form of objects is called the space sense, which finds its numerical expression in the visual acuity. The faculty by which we distinguish colours is known as the colour sense, and that by which we distinguish different degrees of brightness is named the light sense. These three faculties are appreciated in the retina, but in different degrees, throughout its extent, and a distinction is made between central and peripheral vision.

Central vision is that of the fovea centralis, and will not be treated of in this book.

Peripheral or indirect vision is given by the remaining portion of the retina, exclusive of the macula. This is, of course, less sensitive for form than the macula, but movement and slight differences of luminosity are detected by it more quickly. The field of vision is investigated by the perimeter, or, in a rough manner, by the hand, which is useful for detecting the more gross limitations in the field, and the test can be easily and rapidly carried out. One sits at the same level, directly in front, and at a short distance from the patient. The opposite eyes (R. and L., or L. and R.) of patient and observer are closed, and the open eyes look, and continue to look during the whole time, directly at one another. The observer moves his hand from the periphery inwards in the four principal meridians at an equidistance between himself and the patient, and if the latter's field be

normal, both the observer and he will see the hand at the same distance. This is a very useful procedure, and, where no perimeter is available, will often afford valuable evidence in cases of suspected glaucoma, etc.

The normal field does not extend equally in all directions, but it reaches furthest to the temporal side (over 90°), and is much less extensive at the nasal and upper parts of the field, due partly to the projection of the nose and eyebrows, and also partly to the fact that the outer and lower parts of the retina are less practised in seeing than are the upper and inner parts, and consequently their functions are less developed. The field extends outwards 95°, upwards about 53°, inwards about 47°, and downwards about 65°.

The field for colour varies according to the size and intensity of the coloured squares used, and when large and bright these will be distinguished up to the extreme limits of the field, but when examination is made with coloured squares of paper 1 to 2 cm. in diameter the most peripheral parts of the retina are found to be colour blind. The visual field for blue is the largest, yellow being next, then red, green being the smallest. The examination with colours is a more delicate test than with white, and further, it gives some information as to the nature of the lesion, for a lesion of the percipient elements (rods and cones) causes a diminution of the field for blue, whilst a lesion of the conducting elements (affection of the optic nerve, such as toxic amblyopia) causes a diminution in the perception of red and green.

The pathological alterations of the visual field consist in its contraction, or there may be gaps, called scotomata, which lie like islands within the field of vision. The contraction of the field may be more or less equal all round, and we then call it a concentric contraction. When contraction is considerable, as in retinitis pigmentosa, and also occasionally in glaucoma, even though central vision be good, the patient experiences great difficulty in walking about alone, owing to his only seeing those objects which lie directly in his line of vision. This can be personally experienced by fastening a long tube in front of the eye, permitting of little more than direct vision, when the importance of peripheral vision in orientation will be appreciated. The contraction of the field is sector-like in detachment of the retina and embolism of a retinal artery.

Scotomata are distinguished according to whether they are perceived entoptically (positive scotoma) or not (negative scotoma).

A positive scotoma is a dark spot which the patient perceives in his visual field, and its cause may lie in the refracting media or the retina, the opacities in the media casting shadows upon the retina and becoming visible as dark spots. If the opacities are in the vitreous, they move independently of the eye, and are called motile scotomata. Fixed scotomata originate either from opacities in the cornea or lens, or from changes in the fundus, and they are most readily perceived when gazing at a uniformly bright surface.

A negative scotoma is one which is not perceived by the patient, but only discovered when the visual field is examined. It is called absolute when all perception of light is deficient within the limits of the scotoma, and relative when it is limited merely to non-recognition of colour.

THE FUNDUS OF THE RETINA.

The normal appearance of the fundus presents so many variations as to necessitate a detailed account of them, in order to prevent their confusion with pathological conditions.

In the examination of the fundus with the ophthalmoscope the various parts must be observed in the following systematic order:—(1) The disc. (2) The macula. (3) The outer, inner, upper and lower parts of the retina.

(1) *The Disc.*—In order to bring this into view, the patient's eyes must be directed horizontally about 15° inwards. In the indirect examination this is attained by directing the patient to look at the observer's ear. The following points with regard to the disc should be noted: (*a*) The size and shape; (*b*) the margin; (*c*) the blood vessels; (*d*) the relationship of the plane of the disc to that of the adjacent part of the retina; (*e*) the colour.

The shape of the disc is generally circular in outline, but in astigmatism it appears oval, with its long axis in the direction of the meridian of greatest refractivity, thus, when the astigmatism is with the rule, the disc appears as a vertical oval by direct ophthalmoscopic examination. The papilla or disc often has, in reality, an oval form, and in order to distinguish whether we are dealing with a disc that is anatomically oval, or with astigmatic distortion of a round papilla, we must resort to a comparison with the inverted image. If the disc is really a vertical oval in shape, it must also appear so when viewed by the indirect method, but if the shape be an astigmatic effect, then the distortion, as seen by the indirect, will be the opposite to that as viewed by the direct, viz., a transverse oval. This only applies when the convex lens is held close to the patient's eye.

The size of the disc apparently varies a great deal, due to the different degree of enlargement under which the papilla is seen, for the true size of the papilla in enucleated eyes is almost always the same—about 1.5 mm. in diameter.

The margin of the disc is generally clearly cut and well defined, though it is not unusual to find the nasal margin a little obscured, because of the greater number of nerve fibres which happen to cover it.

Surrounding the disc, we often recognise two narrow rings of different colour. The inner one, lying next to it, is white, and is called the scleral ring, its white colour being due to the sclera, which is here exposed to view. It is present when the canal in the sclera, through which the optic nerve passes, is narrowest, not at the retinal end, as is generally the case, but a little posterior to that, so that the canal, as viewed from the front, forms a funnel, with the base forwards. The wall of this funnel, being formed of

white sclera, is seen by the ophthalmoscope as a narrow white ring. The choroid, at the optic nerve entrance, has frequently an excess of pigment, appearing as a black narrow ring, sometimes complete, and at others incomplete, around its disc. (Plate V.)

The blood vessels of the disc consist of the retinal artery and vein. They divide at the head of the nerve into two chief branches, an upper and lower, but various other branches may be given off. (Fig. 59.)

The ophthalmoscopic differences between retinal arteries and veins are easily detected :—

The arteries are of a bright red color, small, and are generally straight.	The veins are darker, of greater calibre, and pursue a more crooked course.
In the larger arteries a shining white streak is seen running along the centre of the vessels.	The light streak is not commonly seen in the veins, and if present is indistinct.

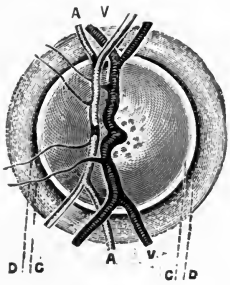


Fig. 59.

Blood vessels of the disc.

A Artery. *V* Vein. *G* Scleral ring. *D* Choroidal ring.

The artery is usually to the nasal side of the vein, and on leaving the disc the vessels commonly cross one another, either vessel passing in front of the other. This causes some pressure on the under vessel, slightly obstructing it, as is manifested by the dilated condition of the vessel peripherally to the crossing. Sometimes the vessels are observed winding around one another, or one forms a loop through which the other passes. Occasionally a cilio-retinal vessel is seen emerging from the disc (Fig. 60), this arising from the short posterior ciliary arteries, which form in the sclera around the optic nerve a small arterial ring, the latter frequently sending a branch to the optic nerve.

A rarer physiological aberration is a persistent hyaloid artery. In fœtal life this artery runs from the retinal artery, through the vitreous, to the posterior surface of the lens, to which it supplies nourishment. At about the seventh month it should disappear, but occasionally it persists, either in its entirety or the central part only disappears, leaving an attenuated portion attached either to the capsule or the disc. In the latter case it is recognised ophthalmoscopically as a thin and more or less opaque filament, arising from the retinal artery and running forwards, its terminal

end lying free, in the vitreous. Its lumen is generally obliterated, hence no blood is present in it. If the persistent part be attached to the posterior capsule of the lens, the ophthalmological picture is the same, but the filament is traced running backwards into the vitreous. If an object is projecting forwards into the vitreous, we may determine it by substituting

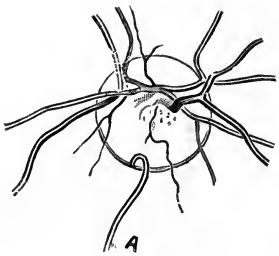


Fig. 60.

From the lower and outer margin of the papilla arises a cilio-retinal artery *A*, making a hook-like bend. The upper retinal vein is seen crossing in front of the artery, whilst the inferior artery lies in front of the vein.

increasing powers of convex lenses, or, in myopia, by inserting weaker convex lenses (direct ophthalmoscopy), and if, when the rest of the fundus is indistinct, the object is distinctly seen, it must be lying in front of the retina, and the stronger the convex lens, or the weaker the concave, with which the object can be seen, the further forwards is it stationed. A difference of level of about 1 mm. corresponds to a difference of refraction of 3 D.

PHYSIOLOGICAL ABNORMALITIES.

Vascular Pulsation.—The human heart empties itself (beats) about 72 times per minute. Each beat is accompanied by a corresponding dilatation of the arteries to accommodate the increased volume of blood, and this may be recognised by the finger as a pulsation wave in any of the superficial arteries of the body, viz., the radial at the wrist, or the temporal in front of the ear. In the smallest arteries and capillaries the pulse wave is so feeble as to defy detection, and usually in the veins no pulsation at all is present. Pulsation is recognised ophthalmoscopically in the retinal vessels by an alternate expansion and contraction of their walls, or, if one of the vessels be distinctly curved, as when bending over a physiological cupping of the disc, a slight to and fro movement is seen in the vessel.

Venous pulsation is commonly seen in the retinal veins in healthy eyes, though very rarely present in other veins of the body.

Donders gives the following explanation of the venous pulse. At each beat of the heart an additional quantity of blood is driven into the arteries of the interior of the eye, causing a temporary raising of the intra-ocular pressure, and the latter compresses the veins on or near the disc, as

the blood pressure in the veins is not only lowest there, but also the vein commonly makes a dip down into the physiological cup. The blood in the vein becomes dammed up, but it rapidly accumulates, and as the venous pressure rises, it is at last able to overcome the compression, allowing the blood to flow on.

This venous pulsation is most readily recognised on the disc, where the vein dips backwards. An arterial pulsation is rare in health, but is commonly seen in glaucoma, and, when present, should always excite suspicion of the latter disease. The pulsation is only seen in the large arteries near the disc. In some forms of heart disease and in exophthalmic goitre (in which disease the eyes are very prominent) arterial pulsation is often seen.

The relationship of the plane of the disc to that of the adjacent part of the retina is such that normally the optic nerve lies on the same plane as the rest of the fundus, or very slightly in front of it.

The disc may lie below the level of the fundus, and is then spoken of as "cupped." This cupping is of two varieties, and it is necessary to be able to discriminate between them. (Plate IV.)

(1) *Physiological Cupping.*—As the name implies, this is normal, of no significance, and arises owing to the central fibres of the optic nerve beginning to separate and crowding over to the border or margins of the nerve before they reach the disc. It is recognised ophthalmoscopically by the fact that the cupping does *not extend to the margins of the disc,* but is confined either to a central part, involving a small or the greater portion of the disc, or to a section of the peripheral part. Such cupping is commonly situated in the outer half, and may extend as far outwards as the margin. It appears whiter than the rest of the disc, and at the bottom of the excavation, in deep cupping, are seen greyish dots, the lamina cribrosa, giving it a mottled appearance.

The retinal vessels generally ascend on the inner side of the cup, and the brilliant white of the cupping forms a vivid contrast with the reddish hue of the unexcavated portion of the disc, but the condition is confirmed by noting parallactic movement. Differences of level of the various parts of the fundus are easily appreciated by this parallactic movement, obtained either by the direct or indirect ophthalmoscopic examination.

To render manifest any cupping of the nerve the observer, in the direct method, fixes any vessel on the disc, preferably a small one, and then makes slight movements of the head at right angles to the direction of the vessel, keeping the latter in view all the time. If the vessel lie only in one plane, the whole of it appears to move in the same direction and at the same rate as the observer's head; but if a portion of the vessel be in a more posterior plane, that part appears to move at a quicker rate than the remaining portion of the artery, but in the same direction. The more posterior the vessel (the deeper the cupping), the quicker the movement. The slightest difference in depth is detected by this method, and it is important that all opticians should be conversant with it. If the cupped

part of the vessel be looked at, then the other portion appears to move in the opposite direction to the observer's movements, but this is not so easy of detection as the former.

Differences of level of the fundus are also made apparent in the inverted image by moving the convex lens, which serves for the production of the inverted image, a little up and down during the examination. If the points of the fundus fixed upon all lie in the same plane, they do not change their relative position to each other with the movement of the convex lens. If, on the contrary, a difference of level exists between them, then a displacement with relation to each other is noted, as at one time they approach nearer to one another, and at another they become further apart.

In pathological cupping of the disc, *the whole of the latter is involved*, right up to the edge of it. This represents often the only ophthalmoscopical difference between physiological and pathological excavations. Pathological cupping is seen in optic atrophy, where it is shallow and saucer-like, and also in glaucoma, where, in the later stages, it is very deep.

Ophthalmoscopic differences between the three kinds of cupping (Plate V.):—

Physiological.	*Optic Atrophy.*	*Glaucoma.*
Involves only a portion of the disc.	Involves the whole.	Involves the whole.
The cupping may be shallow or very deep.	Shallow.	In the early stages shallow, in the later deep.
The excavated part white, the other of good color.	Disc white.	Disc often normal in colour, even in later stages.
Vessels emerge from disc generally slightly to inner side of centre, and are of normal size. Venous pulsation occasionally present.	Vessels normal in position, but of small size.	Vessels arise close to inner margin of disc. The arteries are small and the veins distended. Venous pulsation is common and sometimes arterial pulsation is also seen.

The normal colour of the disc varies greatly, from a lightish grey to a yellowish red, so that little reliance can be placed upon it for the recognition of pathological changes. To a large extent its colour is dependent upon that of the neighbouring retina, for instance, when the nerve fibres are opaque, the disc appears red by contrast. The excavated portion in physiological cupping is whiter than the rest of the disc.

(2) *The Macula.*—This is a little more difficult to see than other parts of fundus, owing partly to the greater contraction of the pupil, caused by the projection of light on to the macular area, and partly to the annoying light reflexes, but both these difficulties are surmounted by practice, and the macula should then be easily seen without a mydriatic. To obtain any details the direct examination must be used. If the observer is in the proper position, it is only necessary for the patient to look straight at him—a movement of the eyes only, not of the head—in order to bring the macula into view. This region lies at about the same level as the disc, and approximately the width of a disc and a half to its outer side. If one is

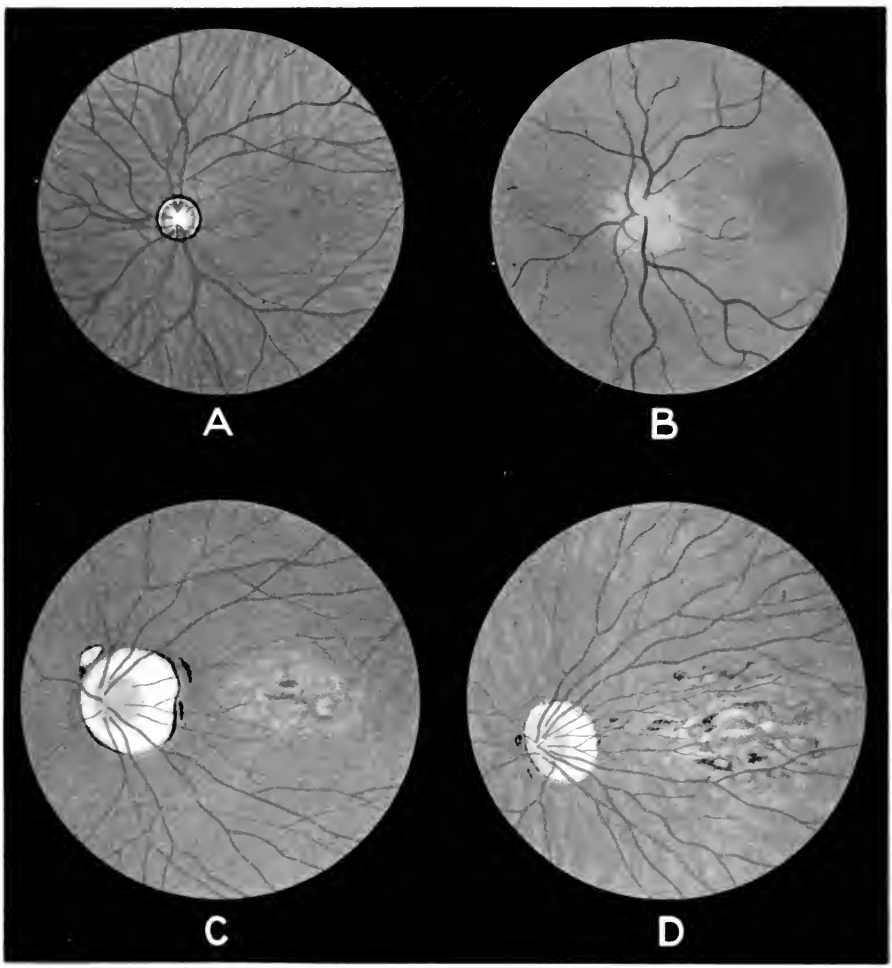


PLATE VII.

A. NORMAL FUNDUS OF A FAIR MAN.

Note. Well defined disc, with inner white scleral and outer black choroidal ring. Arteries lighter and smaller than veins. Physiological cupping of whiter colour. Macular a darkish red circular area. Over all the flatter and wider choroidal vessels, with no central reflex, branching irregularly, and freely anastomosing with each other.

B. NORMAL FUNDUS.

Note. Disc not so clearly defined. Retinal arteries smaller and paler than veins. No cupping. Macular a circular area. Choroidal vessels are not seen, owing to retinal pigment layer being well developed.

C MYOPIC FUNDUS.

Note. Posterior staphyloma invests the disc, which is bordered by pigment. Buff colored mottling of macular area caused by partial atrophy of choroid, characteristic of early myopic changes. Also recent hæmorrhage.

D Ditto, more advanced.

Note. Buff colored spots replaced by irregular pigmentation, with whitish streaks from atrophy of choroid. Diminution of retinal pigment allows choroidal vessels to be seen as light colored lines.

unable to see the macula in this position, it is best to look slightly outwards through the nasal portion of the cornea, whilst the patient's eyes are also directed a little out, or, with the patient's eyes turned well out, the observer transmits the light, in an inward direction, through the other part of the cornea. The macular area is generally well defined from the rest of the fundus, owing partly to the greater contraction of the pupil, caused by the shape. The colouring is deepest around the centre of this area, but in the centre itself a small white or yellowish spot is seen. The macular area is, in size, about half that of the papilla, and is devoid of blood vessels.

Occasionally, especially in fair people, the macula appears to be composed of minute yellow and black points, and this stippled appearance is due to irregular pigmentation of the pigment epithelium of the retina.

Many varieties of light reflexes are seen in the different maculæ, and they can be recognised as such by the fact that their shape and position vary with the movements of the mirror. Sometimes the reflex appears very bright and of a circular shape, and this is termed a "bull's eye" macula, owing to its similarity to the light of a policeman's lantern.

(3) *The Upper, Lower, Inner and Outer Parts* of the fundus must also be examined. The red glare of the fundus is due to reflection from the choroidal circulation, and not to the presence of the retina, which is transparent. We recognise the latter mainly by its blood vessels, which are prominently in view as they course over the red background, and also in some cases by a faint greyish striation, due to the nerve fibre layer, the latter being most readily seen in dark people. In Europeans this is mostly confined to the immediate neighbourhood of the disc, but in the negro races it is seen all over the fundus, giving the impression of a transparent veil lying in front of the choroid. In children, markedly so in hypermetropes, a white shimmering reflex, termed a "shot silk retina," is commonly seen. It is most plainly observed along the course of the vessels, and is easily distinguished, as the reflexes change their place with every movement of the mirror.

Though the red background of the fundus is due to the blood circulating in the choroidal vessels, the latter are hidden from view by the retinal pigment layer. The more pigmented the latter is, the darker appears the fundus, sometimes even appearing almost grey, whilst the lighter the pigment, the brighter is the red of the fundus.

The choroidal vessels are, however, seen physiologically under two conditions:—

(1) Where the retinal pigment is not very abundant, while that in the choroid is plentiful, being chiefly placed in the interspaces between the choroidal vessels. The fundus appears divided up into irregular elongated islands, with bright red striæ running between them, the latter being the choroidal veins, which are seen to anastomose (unite) freely with each other. The retinal vessels are easily seen running over the choroidal veins. This type is physiological. It is called a "tesselated fundus," and is liable to be confused with disseminated choroiditis by beginners.

(2) In very fair people, especially albinos, the pigment, both in the retina and choroid, is so scanty as to permit of the choroidal vessels being plainly seen. (Plate VII.) The retinal vessels, lying in front of the choroidal, are easily distinguished from them.

Retinal vessels.	*Choroidal vessels.*
Situated in front of the choroidal.	Passing behind the retinal.
They appear round, are sharply defined, and have a bright reflex streak running along the centre.	They appear flat, ribbon-like, and not well defined. No reflex streak is present.
They branch in an arborescent manner, and the divisions do not anastomose with one another.	They branch in an irregular manner, and freely anastomose with one another.

It should be noted that: To see the upper part of the fundus, by the direct method, the patient looks up; to view the lower, down. To see the macular region, he looks outwards; and the nasal, inwards. The patient turns his eye in the direction of the field to be observed.

CONGENITAL ABNORMALITIES.

Opaque Nerve Fibres.—An ordinary nerve consists of central fibres (along which the nervous impulse travels) enclosed in a sheath called the medullary sheath. The fibres of the optic nerve possess this sheath as far as the lamina cribrosa, but lose it on approaching the latter, thus entering the eye without one. (Plate IV.) The nerve fibres are transparent, but the medullary substance is opaque, and occasionally some of the optic nerve fibres, after passing through the lamina cribrosa, regain their medullary sheath, and a characteristic ophthalmoscopic appearance is presented.

The medullated fibres, being opaque, appear as brilliant white glistening streaks, radiating from the disc in a fan-shaped manner, the periphery of the opaque area often having a distinct flame-like appearance. (Plate IX D.) The fibres are generally at the upper and lower borders of the papilla, but occasionally they surround it, the disc appearing, by contrast, of a dark red hue.

The inexperienced might mistake this condition for choroidal atrophy, but the snowy whiteness and flame-shaped appearance of the fibres are very distinctive, and when a retinal blood vessel is seen passing *under* the fibres (in choroiditis the retinal blood vessels are, of course, in front of the white patch), no doubt can exist as to the nature of the ophthalmoscopic picture. The retina is insensitive over the site of these fibres, and, if large enough, a definite scotoma can be mapped out with the perimeter. The visual acuity is often, for no apparent reason, slightly reduced in these cases. The only treatment is the correction of the refractive error.

Crick-dots.—These are a series of highly refractile dots around the disc, lying in front of the retinal vessels. They are of no significance, but are often found in several members of the same family.

ANOMALIES OF VISION.

Hyperæsthesia of the Retina is manifested by an increased sensibility to light, and is often associated with overwork. The patient complains of flashes of light, and a sensation of heat and fatigue in the eyes. Intolerance to light is frequently a prominent symptom. Objective examination is negative, and the treatment consists in the prescription of proper glasses and attention to general health.

Amblyopia.—This is a term applied to defective vision where no visible lesion in the eye is present to account for it. Amblyopia ex-anopsia arises from prolonged non-use of one eye, and is usually associated with strabismus. The media and fundus are healthy, and the field of vision normal, but even with the proper correction the visual acuity is frequently only $\frac{6}{60}$. No squint may be observed, but, on questioning the patient, a history of previous squint is nearly always elicited. No treatment is advisable, as, though the acuity may be increased by the more or less constant use of the affected eye, yet binocular vision is unattainable. If the patient be young (under ten), then efforts should be made to create binocular vision.

Amblyopia from Exposure to Bright Light.—The effects vary according to the length of exposure to and intensity of the glare. In the least severe cases the light causes a temporary paralysis of the retina, lasting a variable time, from a few seconds to several hours in cases of momentary exposure, as is seen after flashes of lightning, or after the glare from snowfields. No objective signs are seen, either in the media or fundus.

If the light be very intense, the retinal symptoms may be accompanied by conjunctivitis, and by abrasions of the corneal epithelium. The conjunctival and corneal symptoms, as a rule, do not appear until some hours after the exposure. In the worst cases macular vision may be lost, owing to atrophic and pigmentary changes occurring in the retina.

Hemeralopia, or Night Blindness.—This is a term applied to any condition in which the visual acuity is greatly diminished when the illumination is less, as in the evening. The symptom is caused by (1) peripheral corneal or lenticular opacities, which, owing to the dilated pupil consequent on the diminution of light, come into the pupillary area, and cause irregular refraction, whilst in ordinary illumination the contracted pupil cuts them off from the pupillary area; (2) diseases affecting the peripheral parts of the retina, as retinitis pigmentosa. In the bright daylight the patient sees fairly well, and experiences no difficulty in going about, but in the evening his visual field is so contracted that he is unable to go out alone. These symptoms are occasionally seen in very debilitated children, when no ophthalmoscopic changes can be seen.

Nyctalopia.—This term is applied to that condition in which the sight is better in a lessened illumination, as at night, than in bright daylight. It occurs in central opacities of either cornea or lens, as under low illumination the pupil dilates, and light gains admittance through the peripheral transparent parts of the media. The diseases of the light-perceiving

apparatus which cause this condition are those which affect the centre of the field, whilst the periphery is undisturbed, as in tobacco poisoning. Here the macular fibres only are affected, and so the patient sees better when the pupil is dilated, as in the evening.

DISEASES OF THE RETINA.

Retinitis.—Inflammation of the retina is generally the result of some constitutional disturbance, as diabetes, syphilis and Bright's disease. The symptoms are those of disturbance of vision, but it is not uncommon to find considerable retinal trouble with fairly good or normal vision, especially when the macular region is not involved. These conditions can only be diagnosed by ophthalmoscopic examination, as their detection by the perimeter, though feasible theoretically, involves such a prolonged and minute examination as to be practically useless.

Ophthalmoscopic Signs.—In recent cases there is a diffused cloudiness of the whole of the fundus, due partly to the presence of minute vitreous opacities. The outline of the disc is hazy, indistinct, and often slightly swollen, and the retinal vessels are much dilated, engorged, and tortuous. Hæmorrhages are frequently seen in various parts of the fundus, and appear as dark red patches, of various shape and size, which contrast with the brighter red of the fundus. If they are situated in the nerve fibre layer of the retina, they appear striate or flame-like in shape (similar to opaque nerve fibres) as the blood spreads along the fibres, but when the hæmorrhages lie deeper in the retina, or in the choroid, they are of rounded or irregular shape. The position of the hæmorrhage or any lesion can also be determined by their relationship to the retinal blood vessels which run in the nerve fibre layer, for if the vessels can be traced over the lesion (either blood or exudate), the latter must be deeper than the nerve fibre layer, whilst if the vessels run underneath (as will be evidenced by their disappearance at the margin of the lesion) the lesion must be situated either in or in front of the nerve fibre layer. Lymph or exudate escapes from the engorged vessels, appearing as white patches, varying in their shape, size and position as the hæmorrhages do.

Retinitis always runs a sluggish course, and though the slightest cases may cause no permanent injury to the retina, yet the latter is generally more or less impaired, but the amount of disturbance of vision depends largely upon the position of the lesion.

The treatment is largely general, and in diabetes early diagnosis is of great importance, as the ordinary dietary is very harmful. In albuminuric retinitis the white spots or exudates are often arranged in a radial manner around the macula, presenting a characteristic picture (Plate VIII.C.), but the hæmorrhages are not so numerous as in diabetic retinitis, though the diagnosis of these conditions is only confirmed by the detection of albumen or sugar in the patient's urine.

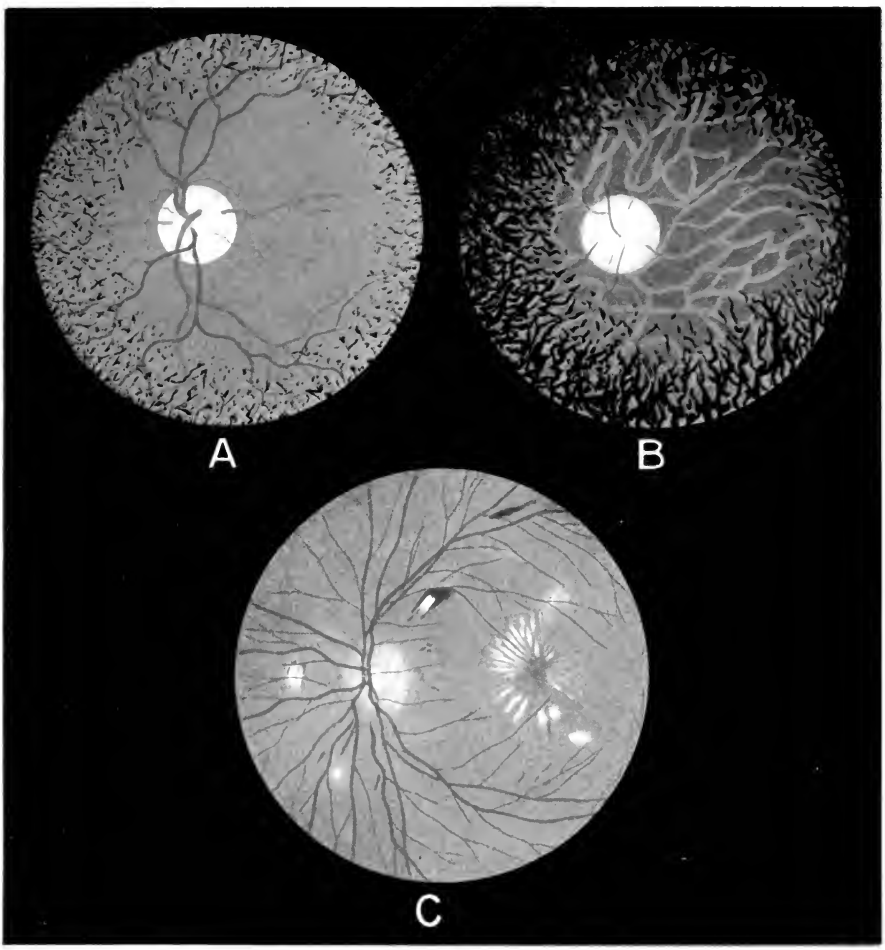


PLATE VIII.

A. FUNDUS IN RETINITIS PIGMENTOSA (early stage).

Note. Spider shaped spots of pigment on periphery, lying in front of retinal vessels.

B. Ditto (late stage).

Note. Disc white and atrophic. Retinal vessels small and thread like. Choroidal vessels as convoluted mass, owing to decolorisation of retinal pigment. Spider shaped spots encroaching centrally.

C. FUNDUS IN ALBUMINURIC RETINITIS.

Note. Edge of disc blurred. Two large and numerous small haemorrhages. In macula, exudate arranged in radial manner so distinctive of albuminuric retinitis.

Embolism of Retinal Artery.—An embolus is a foreign body in the blood stream (either small blood clot, fat cells, etc.), which, when it reaches a blood vessel of smaller size than itself, completely occludes the lumen of the vessel, so preventing the onflow of the blood in it. The retinal arteries are terminal ones (they do not anastomose with one another), so that part of the retina supplied by the occluded vessel is cut off from its nourishment, and gradually dies. The embolus, if large, may block up the central artery, causing a sudden complete loss of vision, or, when small, only one of the terminal branches may be occluded, and a scotoma in the field of vision is complained of, corresponding to the affected area. Detachment of the retina and embolism are the commonest causes of scotoma affecting only one eye.

Diagnosis is confirmed by ophthalmoscopic examination—(1) where the central artery is occluded, the retinal arteries and veins are narrowed, the smaller ones being invisible. The retina, within a few hours, dies and loses its transparency, becoming milky white, especially around the macular area, whilst in the centre of the macula is often seen a bright cherry-red spot (Plate IX.C.) After a few weeks the cloudiness disappears, and the retina becomes transparent again, but is atrophic and functionless. The disc now appears white, and the blood vessels small, the latter often being bordered by white lines. The blindness is permanent, and treatment of very little avail. (2) Where only a branch is affected, on tracing the artery from the disc to the periphery, it will be seen to be normal as far as the occluded spot, when it at once becomes smaller and paler (owing to absence of blood), being continued on as a thin filamentous thread.

Retinitis hæmorrhagica.—This is caused by a thrombus blocking a vein. A thrombus is a blood clot which forms when a part of the inner wall of the vein becomes roughened from any cause whatever, and though the clot is at first slight, yet it gradually grows until it occludes the vessel. The blood is being continuously pumped into the vein, but it cannot flow back to the heart owing to this obstruction, so it bursts through the venous wall into the surrounding tissue. In the retina these hæmorrhages become very numerous, but they only lie along the course of the obstructed vein, the latter being enormously distended.

Retinitis pigmentosa.—This is a degeneration of the retina, accompanied in the later stages by more or less atrophy of the optic nerve. It is extremely chronic in its progress, commencing at an early age, and gradually progressing to almost complete blindness in advanced life. In the early stages the child complains of an inability to see at night, when the illumination is low (so-called nyctalopia), but sees quite well in the daytime. This arises owing to the peripheral portions of the retina, the part first affected, being under-sensitive. Later, the field of vision becomes so contracted, even in bright daylight, that the patient is unable to go out alone, though central vision may be quite good. Later on central vision is lost, and blindness, more or less, supervenes.

The disease attacks both eyes, and as heredity is an important factor in its production, no treatment influences its progress. In the early stages

the fundus appears normal, except in the peripheral parts, where numerous small spider-shaped black pigment spots are seen, the latter being connected together by their legs. (Plate VIII.A.) No spots of exudations are present. The pigment spots are often situated in front of the retinal vessels, and, as the disease progresses, the pigment is found encroaching more and more towards the disc. Later the latter becomes pale, owing to atrophy of the retinæ. Whilst the retina is becoming pigmented in this manner, the pigment epithelium is becoming more scanty, so allowing the choroidal vessels to be distinctly seen. (Plate VIII.B.)

These changes arise from the choroidal capillaries (which supply nutriment to the rods and cones and outer layers of the retina) becoming narrowed, and finally obliterated. As a result the rods and cones do not receive their proper nourishment, and this leads not only to a diminution of the pigment in the retinal pigment layer, allowing the choroidal vessels to be seen ophthalmoscopically, but also to a migration of the pigment cells into the retina, where they form such a characteristic ophthalmoscopic feature.

Detachment of Retina.—By this is meant a separation—either partial or complete—of the retina from the choroid upon which it merely lies, being connected to it only at the optic nerve entrance and the ora serrata. In the dissected eye it can with ease be separated from the choroid, except at its two points of attachment. In the living eye the retina is kept pressed against the choroid by the vitreous, and it may become detached either when this pressure ceases to act, or when the retina is pushed from its bed by a force greater than the pressure of the vitreous, as in a choroidal tumor.

The diminution of the vitreous pressure may be due to its escape following an operation or from a wound, but it is more commonly caused by a shrinkage and liquefaction of the vitreous, consequent on a disturbance of its nutrition. The latter commonly occurs in myopia, and as the sub-retinal fluid, which collects between the choroid and the retina, looks like yellow serum, these kinds of detachments are called serous. Far less frequent are those detachments caused by an active propulsion of the retina away from the choroid, which may be due to hæmorrhage from the choroidal vessels, or to a choroidal tumor. Serous detachments generally commence in the upper part of the fundus, but the fluid gravitates, and ultimately settles in the lower part, hence it is most commonly seen here. The detachments may be slight or extensive, involving a part or the whole of the retina.

Symptoms.—The patient often complains of the sudden appearance of a sort of cloud obscuring the vision of one eye, and examination of the field of vision will disclose a scotoma corresponding to the detached portion of the retina. The vision is affected according to the position and extent of the detachment, and central vision may be quite normal, if the macula and its immediate neighbourhood are intact. Its detection is made by ophthalmoscopic examination, which presents a distinctive appearance.

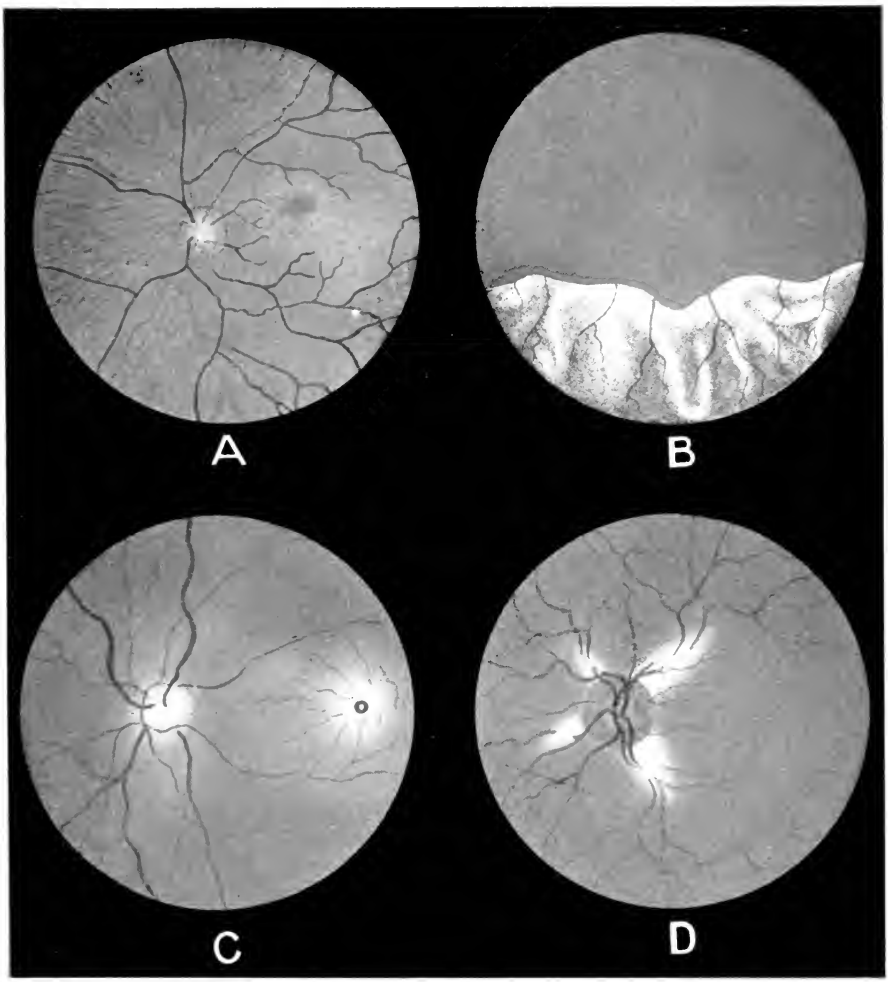


PLATE IX.

A. FUNDUS OF SHALLOW DETACHMENT OF RETINA, INVOLVING MACULAR REGION.

Note. Dark color and tortuosity of retinal arteries. Slight opacity of retina inferred from the obscuration of choroidal markings seen elsewhere.

B. FUNDUS OF DETACHED RETINA.

Note. Dark and tortuous vessels with no reflex streak. Retina opaque, and rest of fundus not in focus, as detached area was best seen with -5 D.

C. FUNDUS OF EMBOLISM OF CENTRAL ARTERY.

Note. Arteries narrow, and veins wider than usual. Loss of transparency of macular area, and the cherry red spot.

D. FUNDUS OF OPAQUE NERVE FIBRES.

Note. Disc red by contrast with white patches of medullated fibres. Retinal blood vessels both in front and behind patches, which are continuous with disc, and are flame shaped at margins.

Ophthalmoscopic Signs.—In the early stages the detached portion of the retina appears of the same colour as the rest of the fundus, but it gradually becomes opaque, appearing of a light greyish colour, and of a dull lustre. The appearance of the blood vessels is most distinctive, as their light reflex is lost, and they are darker, often appearing nearly black, and more tortuous (following the folds of the retina) than those on the rest of the fundus. They also lie further forwards, and so when in focus the rest of the fundus is out. (Plate IX.A.)

In large detachments there can be seen folds in the retina, the tops of these showing a whitish sheen. (Plate IX.B.) Tremulousness can be elicited with movement of the patient's eye.

In a flat shallow detachment no retinal folds nor tremulousness is present, and the diagnosis rests upon changes in the vessels, which are best seen at the junction of the detachment with the healthy retina.

In total detachment, the retina lies just posterior to the lens, and is best seen with a + 10 D. It appears as a whitish, wrinkled membrane, whose nature is only rendered apparent by the detection of the retinal vessels coursing over its surface.

By far the commonest cause of a detached retina is myopia, but if the detachment occurs in an eye otherwise normal, one should always suspect a choroidal tumor. This spreads so quickly, and is so dangerous to life, that for successful treatment early recognition is essential. The appearance of hæmorrhage or new blood vessels in the detached area is a conclusive sign of tumor.

The treatment of detached retina is disappointing. Rest in bed for six weeks is advocated by some, but the fluid only gravitates to the upper part, to return again to the lower after the patient has been up some time. Operative interference, as the introduction of a knife through the sclera into the detached area, allowing escape of the fluid, occasionally gives a good result, but if degeneration of the vitreous be present the condition will recur. The futility of treatment becomes readily appreciated when we remember that this affection is generally only a symptom of vitreous degeneration, the latter being caused by posterior staphyloma (myopia) and ciliary changes of long standing.

Glioma of Retina.—This is a tumor which occurs in early life (from one to six years). It is very liable to recur, and unless the eye be removed at once a fatal issue follows. There are no external changes in the eye, which, except in the very early stages, is quite blind. Later there is noticeable in the pupil a whitish mass with a lustrous appearance, and it is this which first attracts the parent's attention, the patient being usually too young to complain of any disturbance of visual acuity.

THE OPTIC NERVE.

Chapter XIII.

ANATOMY.

The optic nerve collects its fibres from the retina, and passes from the eye through the orbit into the brain. Three divisions of the nerve are distinguished (Fig. 44):—

(1) Intra-ocular Division.—Passing from the retina to the exterior of the eye, the nerve pierces the choroid and sclera at a spot a little to the inner side of the posterior pole of the eye. This is the weakest part of the eyeball, and is the first to give way when the intra-ocular pressure rises, as in glaucoma. This opening in the sclera, through which the nerve passes, forms a short canal called the "scleral canal," and is composed only of the innermost layers of the sclera—the lamina cribrosa—which are perforated by numerous small openings for the passage of the optic nerve fibres. The choroid takes practically no part in the formation of this canal, ceasing at the edge. The outer layers of the sclera are continued from the eyeball on to the orbital part of the optic nerve, forming one of its sheaths. The optic nerve, as it passes through the scleral canal, becomes very much narrowed, owing to its fibres shedding their medullary sheath. (Plate IV.)

The part of the optic nerve in front of the lamina cribrosa is called the head, and it is that which is seen by the ophthalmoscope. As already stated, it lies at the same level as the rest of the fundus.

(2) Orbital Division of the Optic Nerve.—This lies between the eyeball and the opening, or foramen, through which the nerve enters the skull on its way to the brain. Its course is S-shaped, in order to admit of free movements of the eyeball; the retinal vessels enter this part of the nerve, about half an inch behind the globe. The optic nerve consists of many fibres—half a million or more—surrounded by three sheaths. The bundle of fibres arising from the macular area is distributed in a definite manner in the optic nerve. At the disc the fibres lie on the outer side, but behind the globe they quickly come to occupy a central position in the nerve. This bundle is a large one, consisting of quite a quarter of the total number of fibres.

(3) Intra-cranial part of the Optic Nerve.—This is very short, and extends as far as the optic chiasma, where the two optic nerves join together, the inner fibres of each crossing over to join the fibres of the other side. Each nerve, now called the optic tract, thus contains fibres from both

retinæ, and they are continued up to the various centres in the brain, including those which control the pupil and accommodation. As the fibres from the inner half of the retina cross over to the other side at the chiasma, a lesion (an interruption in the conduction of the impulse by the nerve) before the crossing will cause blindness of that eye only, whilst a lesion, say, of the right optic tract, will cause loss of sensibility in the outer half of the right retina, and also in the nasal half of the left, and so both left visual fields will be absent. This is called homonymous hemiopia, and indicates a lesion of the optic tract. A lesion in the centre of the chiasma would cause a loss of sensibility of the nasal halves of both retinæ, and so the temporal field of vision in both eyes would be lost. This is called "temporal hemiopia."

CONGENITAL ABNORMALITIES.

Coloboma of the Optic Nerve.—This is a rare affection, and is due to non-closure of the posterior portion of the fœtal cleft. Either a deep depression is found in the lower part of the disc, or the entire optic nerve entrance is enlarged to several times its usual size, the vessels appearing to be forced apart (Fig. 61). The nerve fibres are either aggregated around the margin, or they may be placed in the upper portion of the papilla.

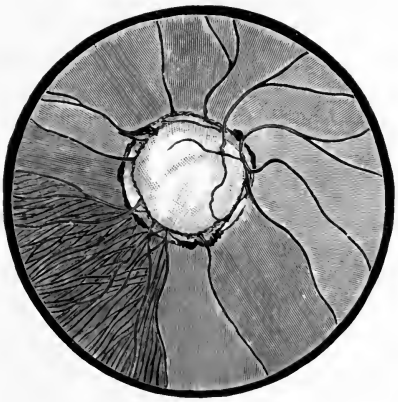


Fig. 61.
Coloboma of the optic disc.

DISEASES.

Inflammation of the Optic Nerve, or Optic Neuritis.—Three kinds are commonly described:—

(1) Neuro-retinitis, in which the inflammation affects the head of the nerve and the adjacent parts of the retina.

(2) Retro-bulbar neuritis, in which the disc is not inflamed, and so appears normal ophthalmoscopically, but the macular bundle of nerve fibres in the orbit behind the eye is affected.

(3) Papillitis, or choked disc, which is really not an inflammation; the disc appearing swollen owing to interference with its lymphatic circulation.

Neuro-retinitis.—This inflammation affects the head of the optic nerve (disc), and extends some short distance along the trunk, involving also the contiguous portion of the retina. It is most frequently caused by anæmia, syphilis, and chronic Bright's disease. Vision is often unaffected in the early stages, but later it is diminished, thus recognition at first is only possible by ophthalmoscopic examination, which reveals an indistinctness of the margins of the disc, the latter appearing much larger than usual, owing to the exudation extending on to the adjacent retina. The veins are engorged and tortuous, whilst the arteries are generally smaller. The most important sign is the swelling of the disc, as evidenced by parallactic displacement. When the vessels on the disc are fixed, those on the fundus appear to move quickly with the observer's head, as they lie at a lower level, or if the vessels on the fundus be fixed, those on the papilla appear to move in the opposite direction to the observer's head. The disc can also be distinctly seen by a higher convex, or lower concave, lens than the rest of the fundus. The colour of the disc is altered, being often mottled with white spots (exudate) and red ones (hæmorrhage). Various hæmorrhages and exudates are also seen in the surrounding retina.

This affection runs a very chronic course, often taking months for the inflammatory symptoms to subside. In severe cases the disc gradually gets paler as the swelling subsides, the margins become well defined, the eye becoming more or less blind, but in milder cases the disc may return to a more or less normal state, though vision is always slightly reduced.

Retro-bulbar Neuritis.—In this no ophthalmoscopic signs are visible, as only the orbital division of the optic nerve is affected. It may be acute in its onset and progress, or it may be chronic. The acute form occurs most commonly in women, and may affect only one eye. Central vision is suddenly much diminished, whilst the peripheral remains more or less good. The patient sees better in the evening. On examination of the field of vision a central scotoma, either partial or complete, is found to exist, whilst the peripheral field is normal. The media and fundus appear healthy. This affection is most frequently due to nasal trouble, and the treatment is directed towards detection and removal of the cause.

Chronic Retro-bulbar Neuritis, or Toxic Amblyopia.—The symptoms are similar to the acute, but its onset is slower and more insidious, and it always affects both eyes. The patient complains of an increasing difficulty in reading, which he generally puts down to age, and he states that vision is better in the evening. Occasionally difficulty in recognising colour is noticed. No improvement in vision, or only slight, is obtained by lenses.

The media are clear, and ophthalmoscopic examination reveals very few, if any, changes. In recent cases the disc may appear a little redder than usual, or late in the disease some pallor of the temporal half of the disc may be detected.

Examination of the field of vision reveals a central scotoma, confined at first to colour, but later including form. Green is the first to disappear, and then red. The peripheral field remains normal. The peripheral field can be roughly tested by the hand, whilst to test the central field a small piece of pink blotting paper on the point of a pen is held in front of the examiner's nose. The patient looks at it with one eye, the other being closed. The patient is unable to recognise the colour whilst looking directly at the blotting paper, but if he continues looking at the nose, whilst the paper is moved gradually away, the colour will be recognised.

The commonest cause of toxic amblyopia is excessive tobacco smoking, especially strong tobacco, as shag, and the abuse of spirituous beverages favours its development. Other poisons, such as lead and arsenic, occasionally give rise to this condition.

The treatment consists in abstinence from tobacco and alcohol, iodide of potassium being given internally. If the scotoma has not become absolute, the condition generally gets better in about a couple of months, but where a total central scotoma is present, a complete cure is very improbable.

Choked Disc, or Papillitis.—This is not an affection of itself, but only a sign of an increased pressure within the skull. Usually no eye symptoms are present, but the patient frequently complains of severe headaches, and occasional attacks of vomiting and giddiness, though sometimes slight headaches are all that annoy him. Vision is good, provided no error of refraction be present, and, if so, its correction will improve the sight.

This condition can only be recognised ophthalmoscopically when the following picture is seen. The edges of the disc are fairly well defined, but the vessels are engorged, and the disc is much swollen, the surrounding retina being more or less normal. The absence of hæmorrhages and exudates, and the fairly well defined disc, distinguish it from optic neuritis.

Choked disc is not an inflammatory condition, but arises owing to an increased pressure within the skull, the latter often being caused by a brain tumor or cyst. This increased pressure prevents the return of the lymph which lies between the sheaths of the optic nerve, so resulting in a swelling of the head of the nerve—the most important sign in the diagnosis. The treatment is that of a brain tumor.

Optic Atrophy.—This may develop gradually, without any previous inflammation of the optic nerve (primary atrophy), or it may be the sequel of an antecedent inflammatory condition (secondary atrophy). These two

affections can be differentiated ophthalmoscopically. In optic atrophy the visual acuity is much lowered, and the field of vision is contracted. Colour blindness sets in early, red being lost first, then green, and lastly blue, whilst in chronic glaucoma, which in the early stages might be confused with atrophy, colour blindness does not occur until late in the disease. The pupils are generally dilated, and more or less inactive. In optic atrophy due to spinal lesions the pupil is frequently contracted, and, though inactive to light, it readily reacts to accommodation (Argyle Robertson's pupil). The media are clear, and the diagnosis is made from the ophthalmoscopic appearance, which is as follows in the two states:—

Primary optic atrophy.	*Secondary optic atrophy.*
Edge of disc is clear and well defined.	Edge of disc is irregular, owing to previous inflammatory conditions.
The vessels are smaller than normal.	The vessels are smaller or of normal size, but they have a white streak around them.
There is slight, saucer like, cupping of the disc, extending to its margins.	The disc is rarely cupped, occasionally it is slightly raised when the inflammatory products have not been completely absorbed.
The disc is white, and the greyish markings of the lamina cribrosa are well seen.	The disc is white or bluish white, and the lamina cribrosa is not seen.

The outlook in atrophy of the optic nerve is bad, the patient generally becoming blind, nor does treatment influence it, unless the causal lesion can be attacked with success.

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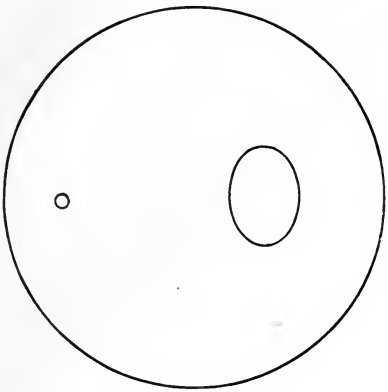

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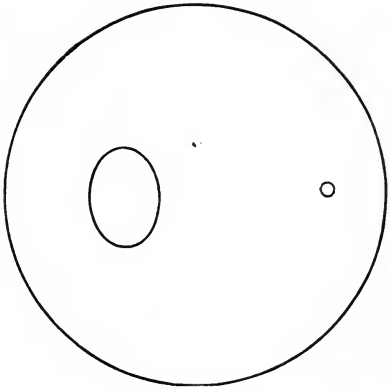

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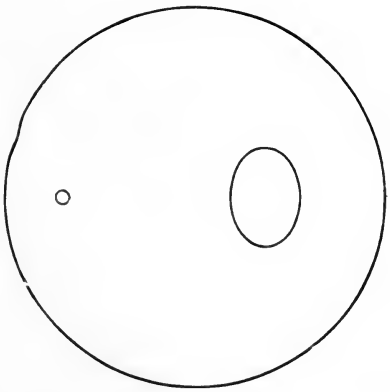

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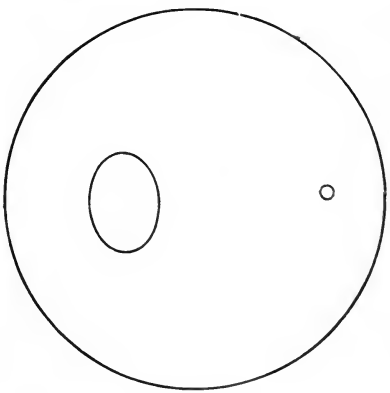

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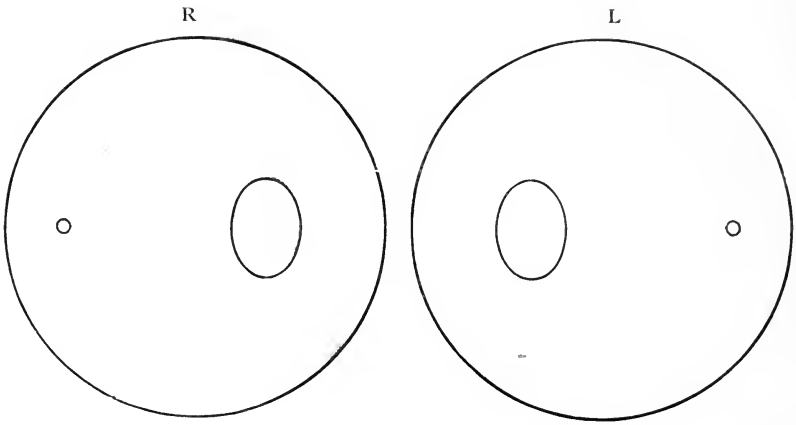

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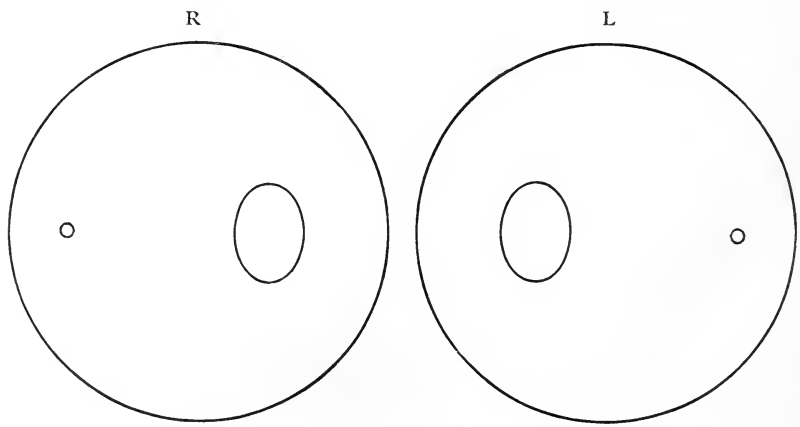

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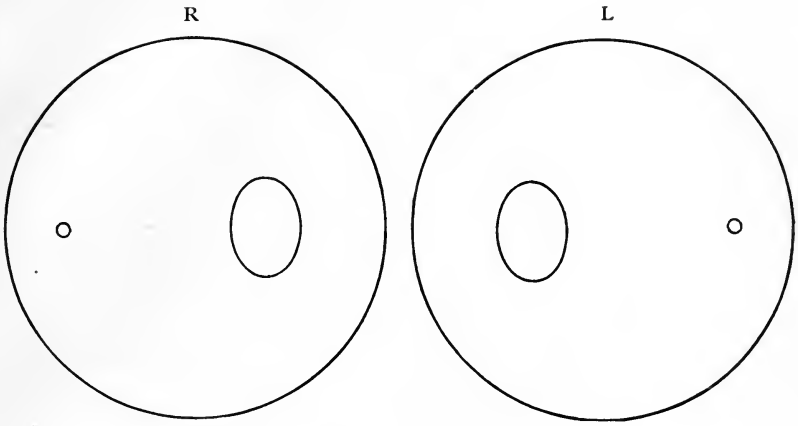

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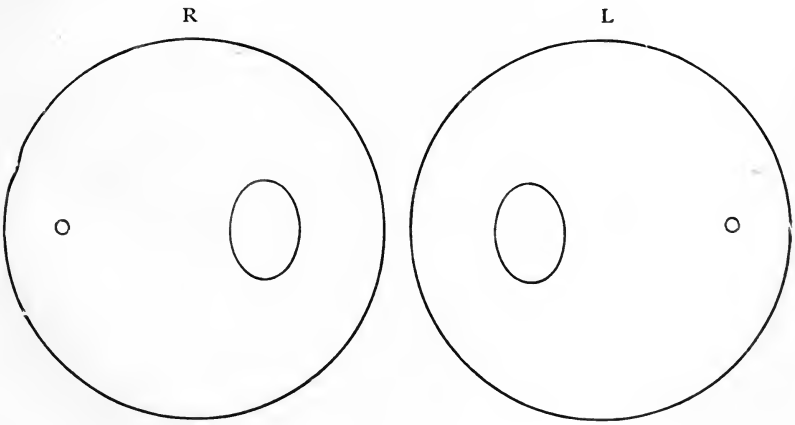

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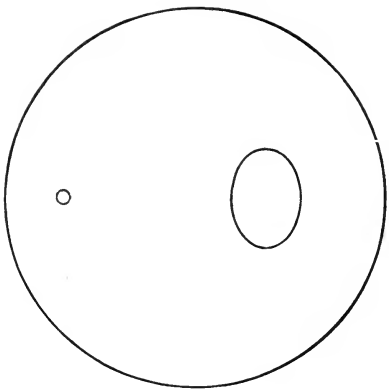

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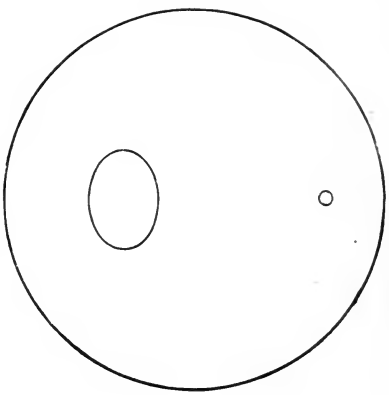

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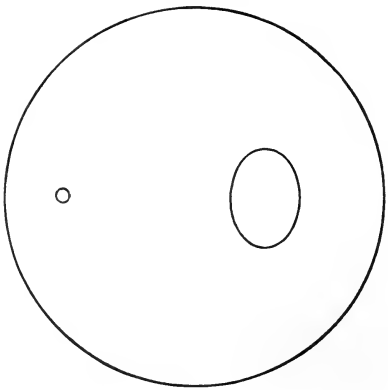

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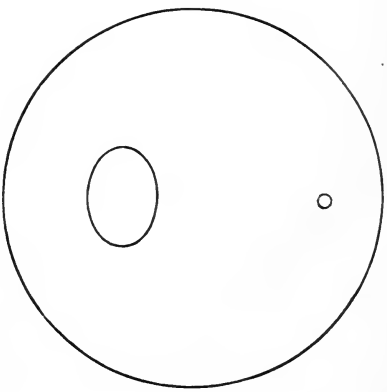

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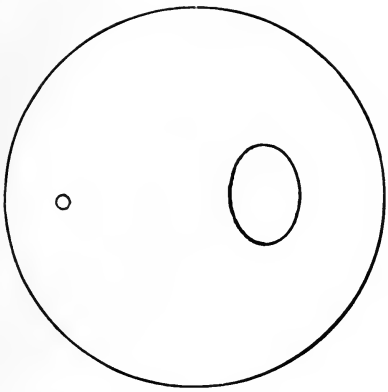

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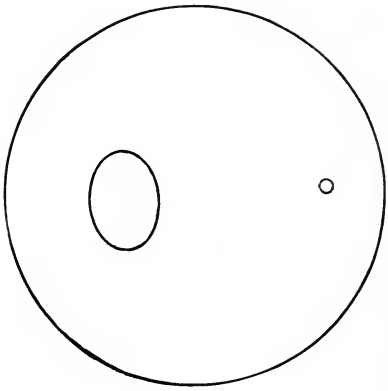

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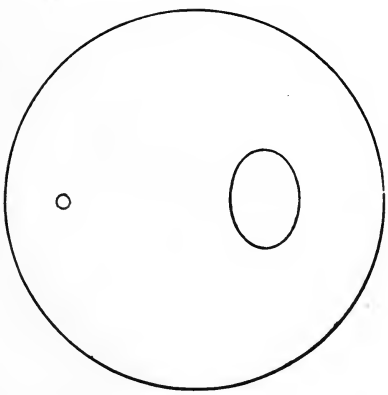

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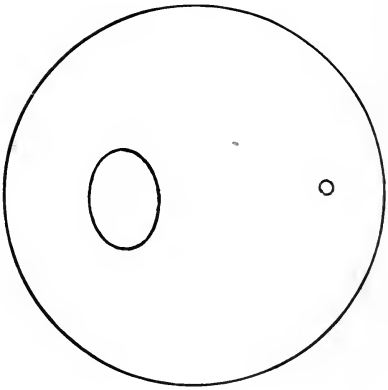

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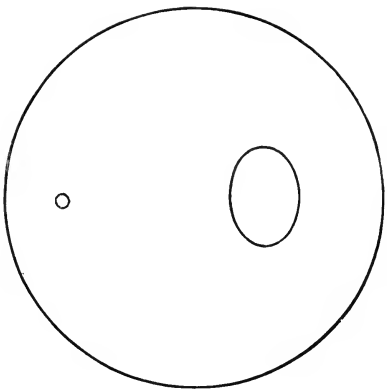

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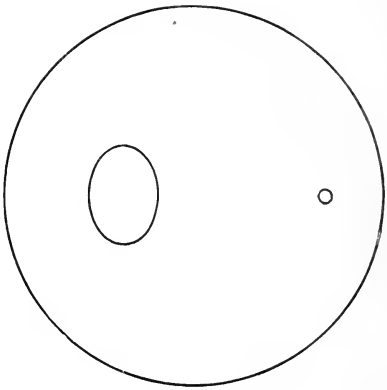

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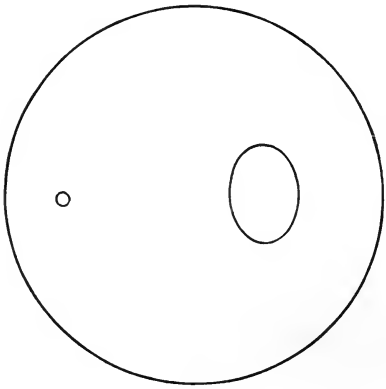

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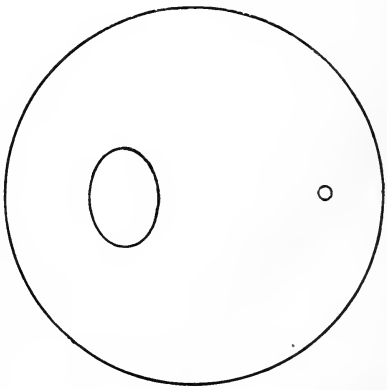

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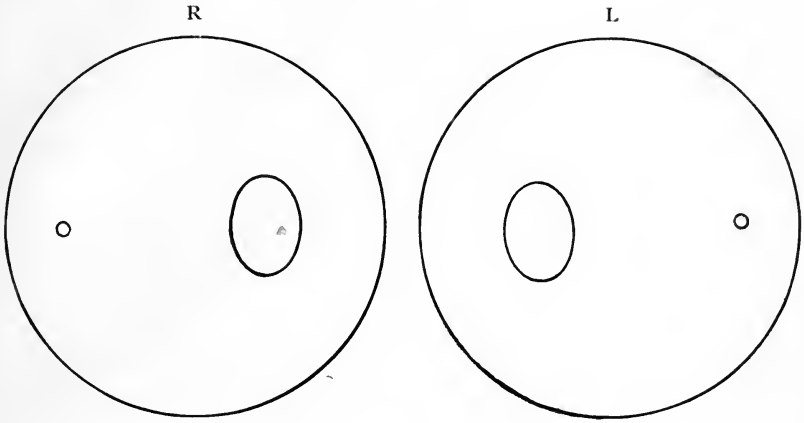

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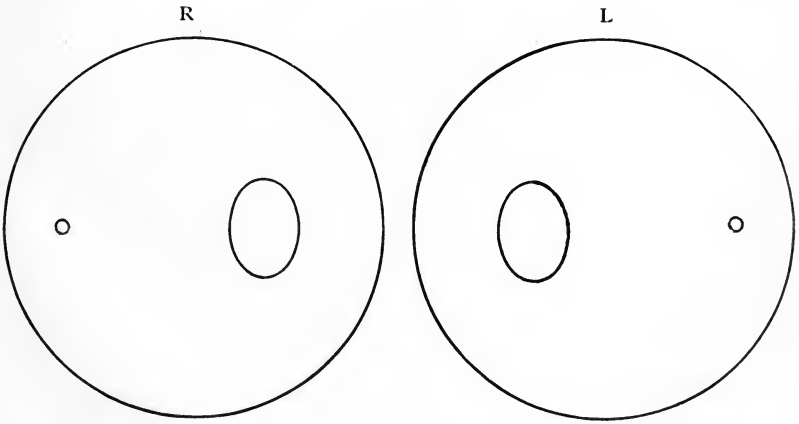

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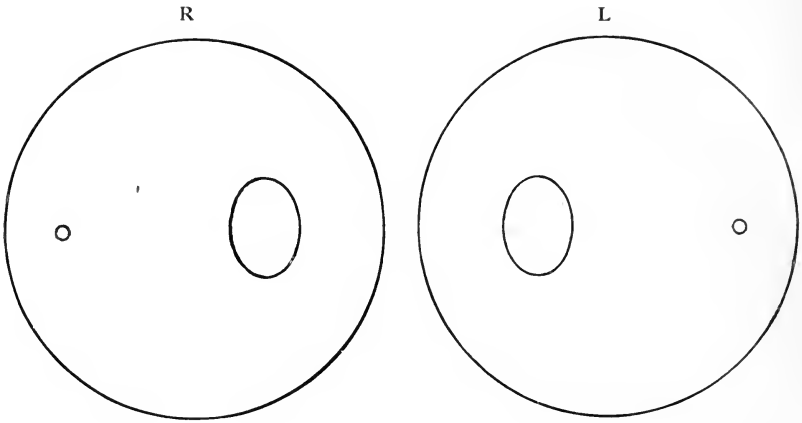

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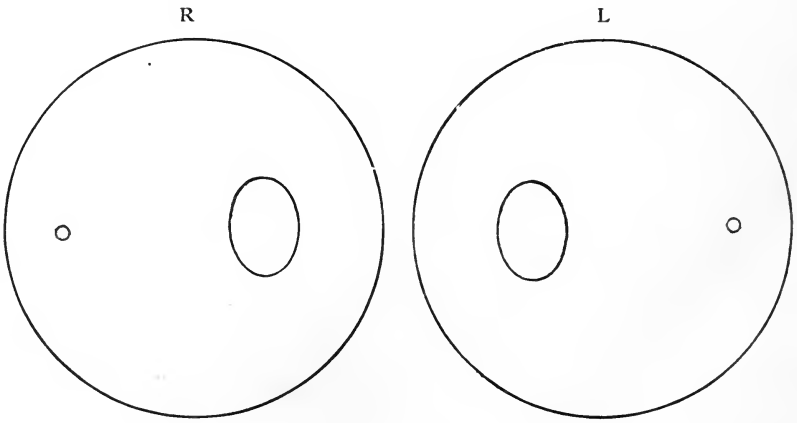

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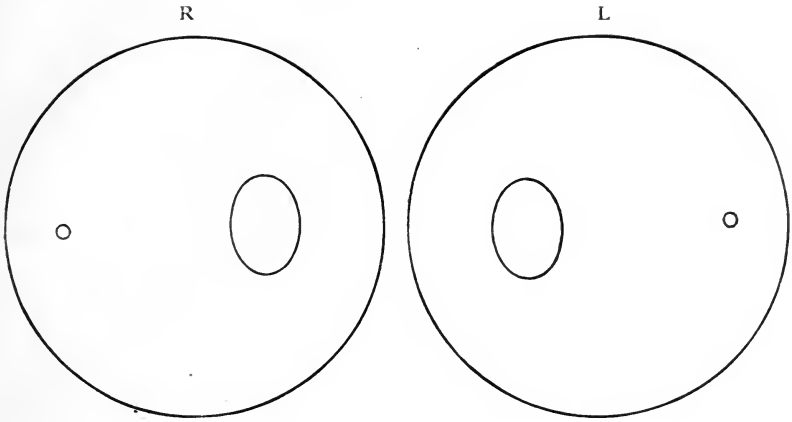

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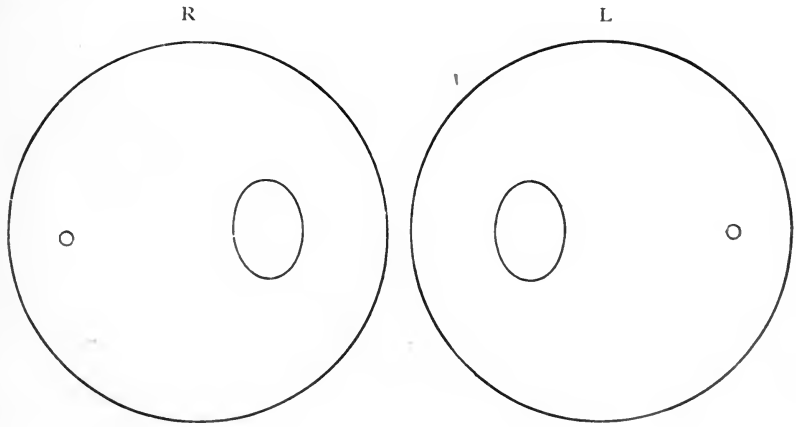

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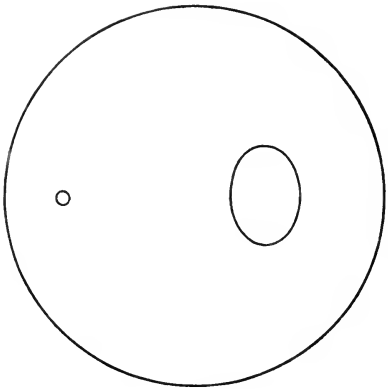

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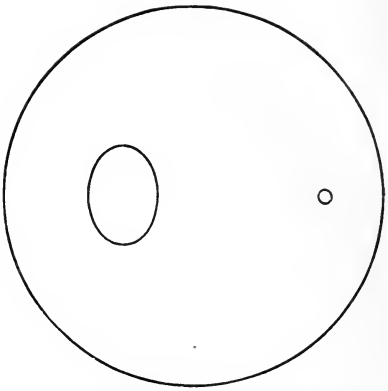

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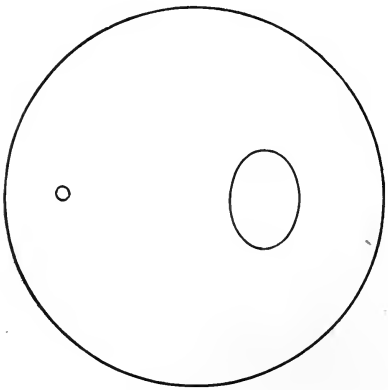

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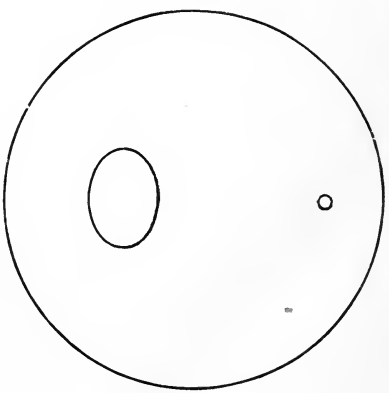

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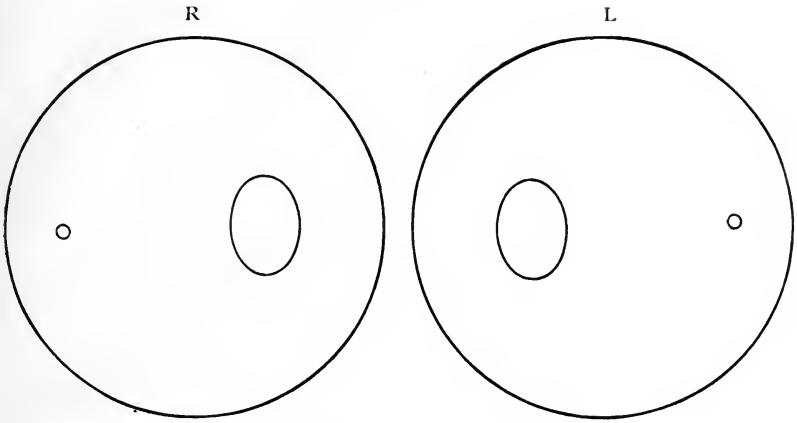

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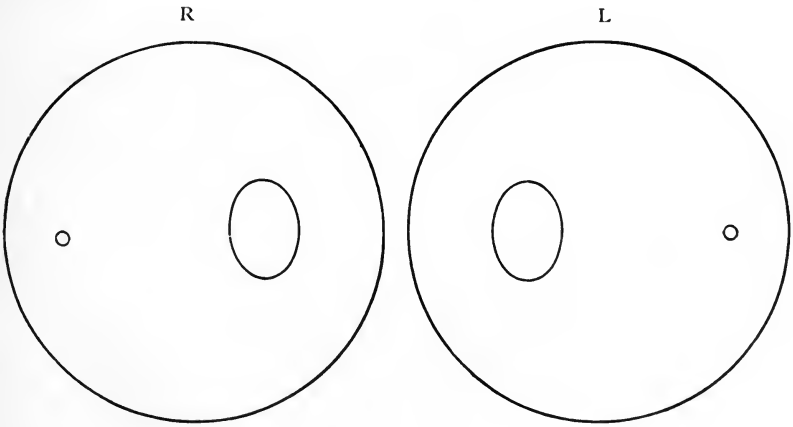

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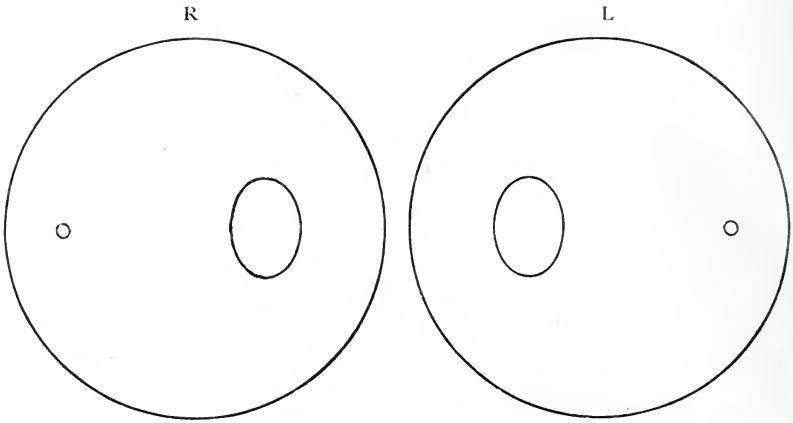

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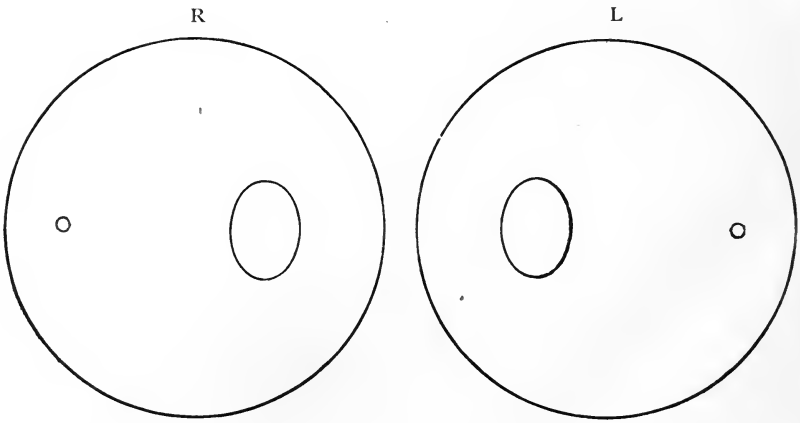

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LIST OF BOOKS

For further study upon Special Subjects.

		s.	d.
OCULAR HISTOLOGY	Histology of the Eye—*C. F. Pollack*	15	0
	Microscopic Examination of the Eye—*R. Greeff*	5	0
OCULAR MUSCLES	Muscular Anomalies of the Eye—*Hansell & Reber*	3	6
	Refraction and Motility of the Eye—*W. N. Suter*	8	4
	Sight—*Le Conte*	5	0
	The Ocular Muscles—*E. E. Maddox*	6	3
OPHTHALMOSCOPY	Atlas of Ophthalmoscopy—*O. Haab*	13	0
	Manual of Ophthalmoscopy—*J. E. Jennings*	7	6
	Pocket Atlas and Text Book of the Fundus Oculi —*L. Johnson*	10	6
PHYSIOLOGIC OPTICS	Ophthalmic Optics—*J. H. Parsons*	6	6
	Physiologic Optics—*M. Tscherning*	10	5
PHYSIOLOGY OF VISION	Curiosities of Light and Sight—*S. Bidwell*	2	6
	Text Book of Physiology (Part IV.)—*M. Foster*	10	6
RETINOSCOPY	Retinoscopy—*J. Thorington*	4	6
	The Keystone Manual of Retinoscopy	4	2
SIGHT TESTING	The Key to Sight Testing (2nd Edition)— *Taylor & Mackinney*	10	6
	Refraction and How to Refract—*Thorington*	7	6

The above may be obtained from

J. & H. TAYLOR, Dioptric Works, Albion St., BIRMINGHAM.

J. & H. TAYLOR (Lond.) Ltd., 33, Kirby St., Hatton Garden, LONDON.

INDEX TO PLATES.

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INDEX.

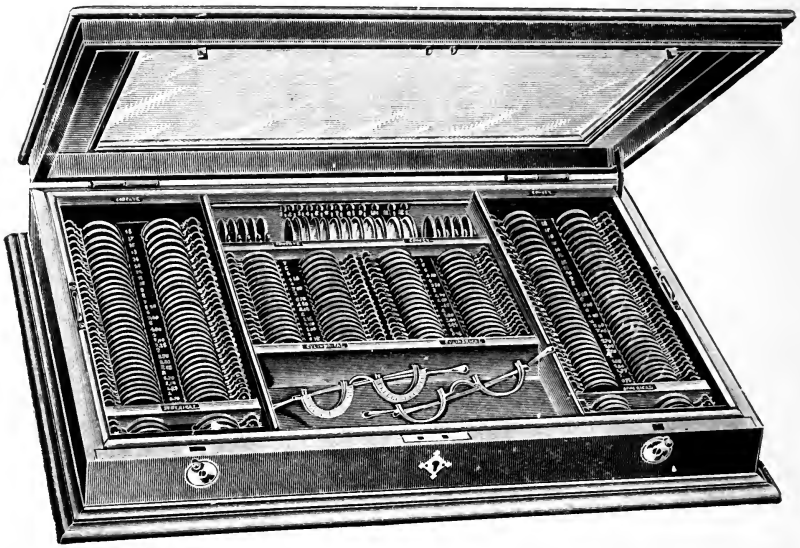
THE FOLLOWING ARTICLES MAY BE OBTAINED FROM

J. & H. TAYLOR, Dioptric Works, Albion St., Birmingham.

. . or . .

J. & H. TAYLOR (Lond.) Ltd., 33, Kirby St., Hatton Garden, London.

TRIAL CASES.



Polished mahogany case, highly finished with bevelled plate glass top, removable lid, tray for lenses to lift out, good fittings and lock, all lenses in fine test rings with pierced handles £8 0 0

Without trial frames ... 7/6 less.

CONTENTS:

30 pairs spherical c/x ·25 to 20D
30 " " c/c ·25 to 20D
18 single cylinders c/x ·25 to 7D
18 " " c/c ·25 to 7D
12 prisms 1Δ to 12Δ
12 blue and smoke glasses
1 each plano ruby, amber, green and white
4 discs
1 single cell trial frame
1 double cell graduated trial frame

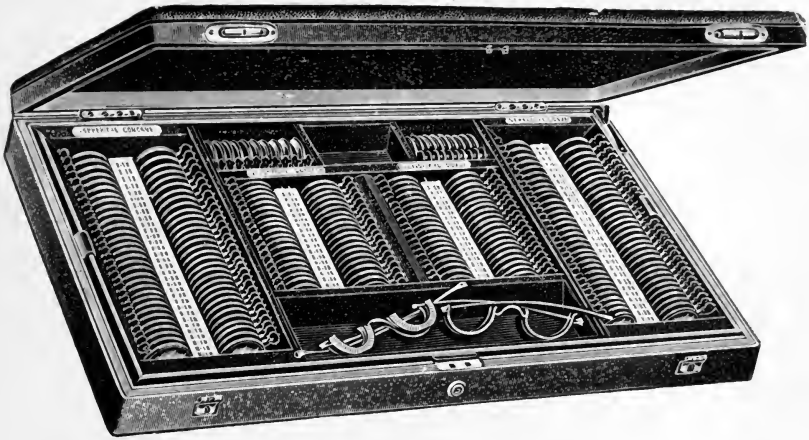
Polished mahogany case, highly finished, with bevelled plate glass top, removable lid, tray for lenses to lift out, good fittings and lock £9 16 0

Without trial frames ... 7/6 less.

CONTENTS:

32 pairs spherical c/x ·25 to 20D
32 " " c/c ·25 to 20D
18 pairs cylinders c/x ·25 to 7D
18 " " c/c ·25 to 7D
12 prisms 1Δ to 12Δ
12 plano blue and smoke glasses
1 each plano red, amber, green, and white
5 discs
1 chromatic test
1 Maddox rod
1 single cell trial frame
1 double cell graduated trial frame

TRIAL CASES—*Continued.*



Leather covered, finely finished case, with velvet and leather fittings, all lenses mounted in tempered nickel plated spun rims £9 0 0

Without trial frames ... 7/6 less.

CONTENTS:

32 pairs spherical	c/x ·12 to 20D	3 coloured glasses	
32 " "	c/c ·12 to 20D	1 Maddox rod	
20 pairs cylinders	c/x ·12 to 6D	6 stenopaic and occluding discs	
20 " "	c/c ·12 to 6D	1 double cell graduated trial frame	
10 prisms	1Δ to 10Δ	1 single cell trial frame	

Or with best standard trial frame, adjustable sides £10 0 0

Contents same as above, but fitted in solid oak case, with plate glass top and drawer beneath, lenses fitted in removable tray £10 10 0

Roll top fumed oak cabinet trial case, removable tray, best work throughout, two drawers £10 12 0

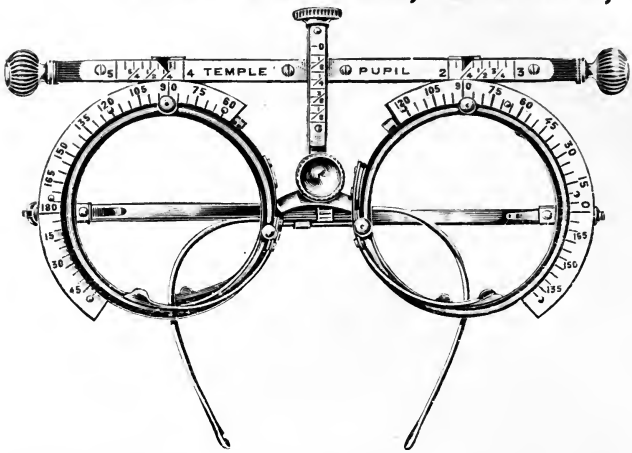
CONTENTS:

35 pairs spherical	c/x ·12 to 20D
35 " "	c/c ·12 to 20D
21 " cylinders	c/x ·12 to 6D
21 " "	c/c ·12 to 6D
15 prisms	1 to 20
14 discs and coloured glasses	

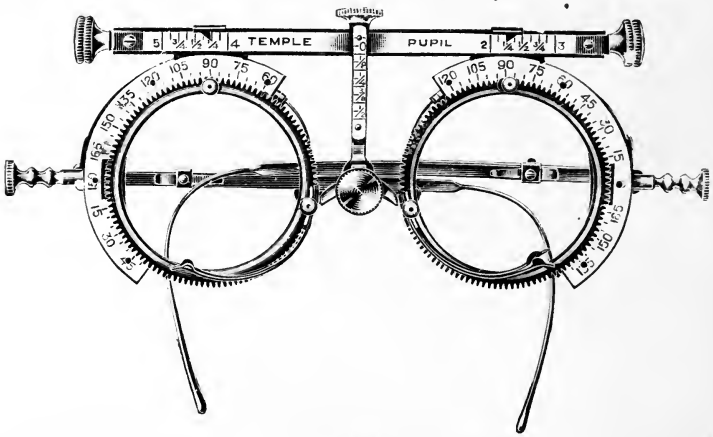
No trial frames are included.

Bifocal trial set, in black seal grain leather covered case. Rings 38mms. Reading segments are cemented on to plano distance, and may be had of any shape preferred by the optician. There are 12 pairs of lenses, from ±·50 to ±3·25 spherical £1 15 0

TRIAL FRAMES, CHARTS, &c.



Patented double cell, extension temples, celluloid scales on eyes and bar, £1 7 6



Three-cell, same as above, but patented revolving cell and thumb screw, best make £1 15 0

Do. do. 2nd quality £1 12 0

Snellen's test type, various letters and arrangements, black letters on white card, per card 1 0

Ditto, cards with metal edge to top ... ... per card 1 0

Per set of four ... ... " 4 0

Snellen's test type, reversed, for use with mirror ... per card 1 0

Test type, white letters on black ground ... ... " 1 3

Snellen's reading type, 8 × 5½in., distances in feet 0 6

Jaeger's test type, folding 14 × 11in., distances in centimetres 0 9

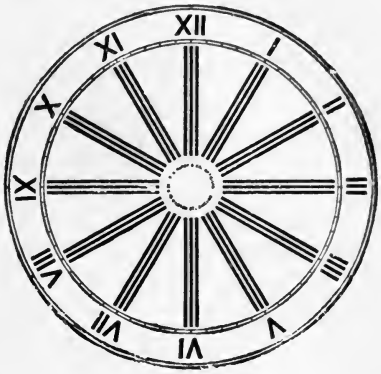
Lionel Laurance chart—Ordinary type, 40 × 25in. 9 6

Reversed type 10 6

Portable chart, 18½ × 12½in. 7 6

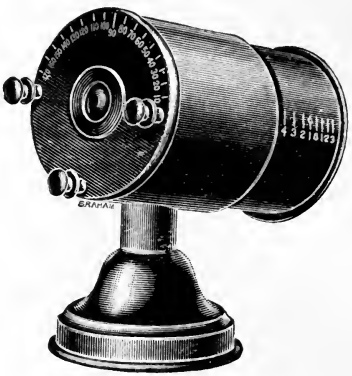
Two extra cards for changing type 2 0

CHARTS AND ACCESSORIES.



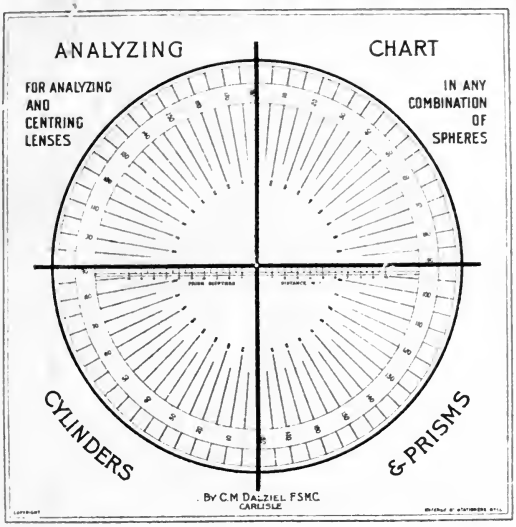
	s.	d.
Astigmatic fan, large size paper ...	1	6
Astigmatic fan, linen, mounted on rollers ...	3	0
Astigmatic clock face (as illustrated) 18 × 18″	1	0
Test type (after Dr. Pray) for Astigmatism, circles	0	6
Test type (after Dr. Pray) for Astigmatism, letters (as illustrated)	1	6
Pinhole disc, black bronzed metal, in nickelled steel frame, with ebony handle	2	0
Stenopaic slit, mounted as above ...	2	0
Stenopaic slit, adjustable for various widths	3	6
Revolving slits and pinholes of various sizes, with spring clip and groove for holding lens	6	0
Disc or lens holder, nickelled steel, ebony handle	1	0
Test ring, with vivid blue, green, or opaque glass	1	0
Maddox rod, white or red, for testing muscular insufficiency (as illustrated) ...	2	6
Maddox triple rod, white or red, for testing muscular insufficiency	2	9
Maddox multiple groove, white or red ..	4	0
Maddox prism, mounted in test ring ..	4	0
Jackson's crossed cylinder in nickelled ring, with handle	2	6
Near point measure, boxwood	5	0
Test cards for near point measure ...	0	6
Retinoscope, plain or concave mirror, with ebony handle	2	6
Thorington's retinoscope (as illustrated) ...	4	6

CHARTS AND ACCESSORIES.

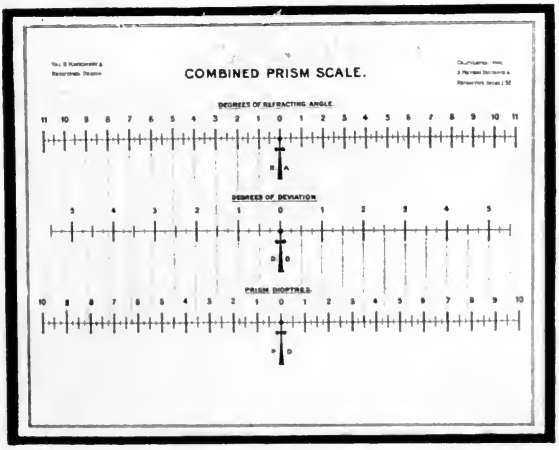


	£	s.	d.
Chambers' Inskeep practice eye for retinoscopy, with sliding brass tube, and concave fundus with good retinal picture	0	5	0
The "Hu-Model" practice eye for Retinoscopy and Ophthalmoscopy. The ordinary refractive conditions of the human eye are represented by the use of 5 solid glass models, which are inserted into a metal tube with iris diaphragm. In morocco case	1	5	0
The "Hu-Model" selection of fundi, to be used with above, the various diseases being reproduced from Haab's Atlas. In case	18	-	the set, or 16 - each.
Asbestos retinoscopic chimney	0	2	6
Asbestos retinoscopic chimney, with iris diaphragm ...	0	8	0
Mackinney's ophthalmic bracket, with electric or gas fittings. This is very simple in construction, and is self-fixing in position by merely releasing the handle which is attached to an eccentric cam. The bars are telescopic, and the whole is highly finished in dead black (chimney is extra)	1	12	6

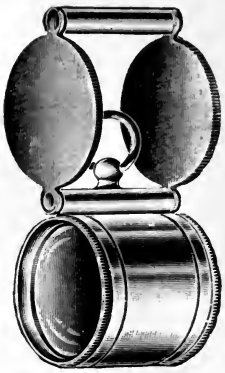
CHARTS AND ACCESSORIES.



	each. £	s.	d.
Morton's ophthalmoscope, best English make ...	2	4	0
Manifold prescription books of 100 pages	0	1	6
Dalziel's chart, for analyzing and centering lenses (as illustrated)	0	3	6
Mackinney's prism chart, for testing the prismatic power of a lens in degrees of refracting angle, degrees of deviation, and prism dioptres. Also useful for testing muscular balance at a near distance	0	2	0



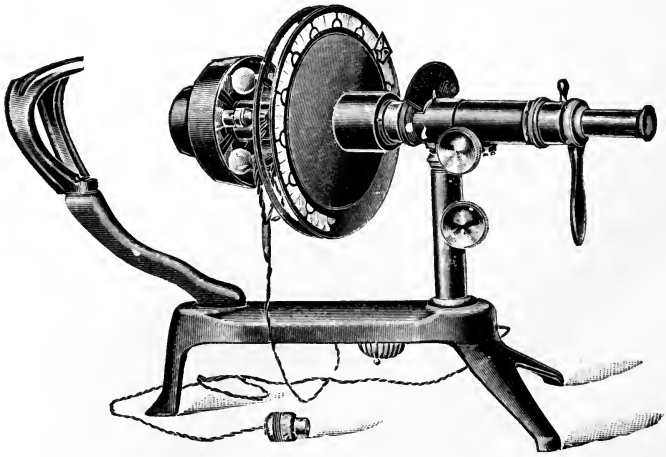
	each s.	d.
Coddington magnifier, nickelled mount, with cover and ring, 1in. diam., for examing the cornea	3	6
The Convergiscope is a binocular magnifier which is affixed to the head by a band, giving a stereoscopic effect to the object examined, with ease and comfort to both eyes. The lenses are fitted to a light straw hood ...	12	6
Condensing lens, diam. 2½in. ; 2½in. or 3in. focus	1	6
Condensing lens, diam. 2½in. ; in strong nickel mounts	3	6



	s.	d.
Reid's test type (reading) on stout folding cardboard. covered leatherette and varnished, with music and time tables ...	1	3
Mahogany frame, open back and front, 9 × 6in., containing test type for reading, with time table on reverse	1	9
Oak frame, as above, closed back ...	2	0
" " with handle (illustrated)	2	6
" " open front and back ...	2	0
Prescription books of 100 pages ... each	1	6
Record books of 100 pages ... "	3	6

THE "NEW" KERATOMETER. This instrument is of British manufacture, and while embodying the simple form of construction found in the older types, is practically a one-position model, with all the advantages of this class of instrument, but with its previous errors eliminated. A booklet describing its construction and use will be forwarded on application.

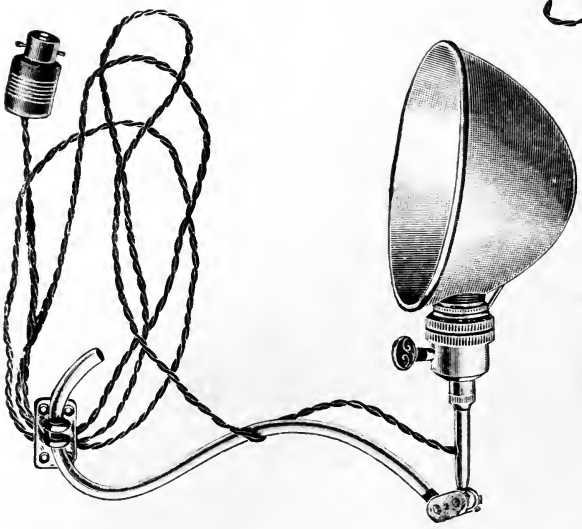
Price, fitted for electric light ... £10 10 0



ADJUSTABLE INSTRUMENT TABLE. This is heavily built of iron, and can be raised or lowered by simply revolving the wheel. The top is of fumed solid oak, the stand being copper plated and bronze finished.

Price	£2 4 0	Packing and case extra.
Adjustable stool ...	1 17 0	" "

Illuminating bracket, strongly made, of nickel plated brass tube, with parabolic reflector and cover, with iris diaphragm. The cover is hinged to the hood and can be swung behind, giving the full illumination of Reflector. An iris diaphragm, graduated in millimetres, is fitted, and three yards of wire with adapter is supplied ... £1 1 0



A similar device to above, with iris diaphragm, &c., and double ball joint (the reflector only being shown).

£1 1 0

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